Deleted: BLACK & VEATCH Building a world of difference

Client Name
RETI Stakeholder Steering Committee

Deleted:

B&V Project
149148.0010

Formatted: Font: Bold

Formatted: Tabs: Not at 6.5"

Project Name
Renewable Energy Transmission Initiative Phase 1A

Deleted:

Version
Draft Final Report

Publish Date
15 April 2008

Formatted: Tabs: Not at 6.5"

Attn: Anne Gillette
Click here to type Company, Name, and Address

Subject: Draft Report Submittal

Dear Click here to type Addressee Name :

Black & Veatch is pleased to submit this Draft Report to RETI Stakeholder Steering Committee for the Renewable Energy Transmission Initiative Phase 1A.

[If report is being submitted for Review, then reference the next step, e.g. face-to-face meeting to review/discuss or perhaps all we need to state when comments are due back.] [If report is Final Issue, then we should state something like this: This Final Issue of the report incorporates comments received on dd/mmmm/yyyy and subsequent phone discussions.]

We trust that this submittal meets your expectations and needs. Should you have any comments, please feel free to contact me at (913) 458-Click here to type Extension .

Very truly yours,

BLACK & VEATCH

Click here to type Signer
Click here to type Title

Click here to type Initials
Enclosure[s]

cc: Click here to type cc(s)

Formatted: Tabs: 6.5", Right

Deleted: Black & Veatch Corporation · 11401 Lamar · Overland Park, KS 66211 USA · Telephone: 913.458.2000

Formatted: Font: 10 pt

Formatted: Footer, Left

RETI Stakeholder Steering Committee

Renewable Energy Transmission Initiative Phase 1A

DRAFT REPORT
B&V Project Number 149148.0010

Contract Manager

University of California, Office of the President
California Institute for Energy and the Environment

April 2008

Black & Veatch Corporation
2999 Oak Rd, Suite 490
Walnut Creek, CA 94597
Tel: (913) 458-2000 www.bv.com

Formatted: Font: Arial, 16 pt

Formatted: Space Before: 12 pt, Border: Bottom: (Single solid line, Auto, 0.5 pt Line width)

Deleted: <sp>

Black & Veatch Principal Investigators:

Formatted: Space Before: 30 pt

Ryan Pletka, Project Manager
Andy Baldock
Keith Cummer
Kevin Gilton
Bret Harper
Cristin Holmgren
Kevin Joyce
Tim Mason
Ric O'Connell
Andy Rawlins
Bill Roush
Larry Stoddard
Sian Wilson
Dave Woodward

Formatted: German (Germany)

Deleted: Claire Legrand¶

GeothermEx – Subcontractor for geothermal sections

Deleted: <sp>

Acknowledgements:

Lloyd Cibulka, California Institute for Energy and the Environment
Nate Blair, National Renewable Energy Laboratory
Rich Ferguson, Center for Energy Efficiency and Renewable Technologies
Donna Heimiller, National Renewable Energy Laboratory
Dave Olsen, Center for Energy Efficiency and Renewable Technologies

Phase 1A Working Group

- Gary Allen – Southern California Edison
- Rainer Aringhoff – Solar Developers
- Joe Bertotti – Regional Council of Rural Counties
- Linda Brown – San Diego Gas & Electric
- Mike DeAngelis – Sacramento Municipal Utility District
- Anne Gillette – California Public Utilities Commission
- Steven Kelly – Independent Energy Producers
- Clare Laufenberg – California Energy Commission
- John McCaull – Geothermal Developers
- Gregg Morris – Biomass Developers
- Dariush Shirmohammadi – Wind Developers

Stakeholder Steering Committee
And, all parties who provided comments and feedback on the initial draft

BLACK & VEATCH

1.0 Executive Summary

Black & Veatch is pleased to provide this report on the Renewable Energy Transmission Initiative Phase 1A activities to the Stakeholder Steering Committee. The purpose of this report is to describe the methodology, assumptions and resource information to be used in Phase 1B of the California Renewable Energy Transmission Initiative project. This work was performed under contract with the University of California, Office of the President – California Institute for Energy and the Environment.

1.1 Background and Objective

California was among the first states to enact a renewable portfolio standard (RPS) and currently has one of the most aggressive portfolio requirements in the country. California has adopted an RPS requiring that 20 percent of electric energy be generated from renewable resources by 2010 (2013 with flexible compliance).[1] The Governor and the state's Energy Action Plan have endorsed a further goal of 33 percent renewables by 2020, in part, as a strategy for meeting the greenhouse gas emission reduction requirements of AB 32.[2] Meeting these RPS goals will require a substantial amount of new transmission development, as most large-scale renewable resources are located in remote areas rather than near the state's major load centers. The Renewable Energy Transmission Initiative (RETI) is a statewide initiative designed to identify and quantify the renewable resources that can provide cost-effective, environmentally sensitive energy to meet the RPS requirements, and also to identify the transmission investments necessary to ensure delivery of that energy to California consumers.

RETI brings together renewable transmission and generation stakeholders in a process to identify, plan, and establish a rigorous analytical basis for regulatory approvals of the next major transmission projects needed to access renewable resources in California and adjacent areas. RETI is divided into three discrete phases. Phase 1 is designed to provide a project level screening and ranking of potential renewable resource zones and to broadly identify transmission requirements to access these zones. Phase 2 will examine generation and transmission in more detail and will develop conceptual transmission plans to the highest-ranking zones. Phase 3 is intended to support

[1] SB 1078 established an RPS of 20% by 2017. The Energy Action Plan, adopted by the Commission and the California Energy Commission (CEC) in May 2003, accelerated the completion date to 2010. SB 107, passed in 2006, codified that policy.
[2] Assembly Bill 32, Ch. 488, Stats. 2006. Executive Order S-3-05, signed by the Governor on June 1, 2005, establishes greenhouse gas emission reduction goals for California and identifies acceleration of the renewable energy goals to 33% of energy sales by 2020 as one strategy to meet those goals. See "Strategies Underway in California That Reduce Greenhouse Gas Emissions" at http://www.climatechange.ca.gov/climate_action_team/factsheets/2005-06_GHG_STRATEGIES_FS.PDF

transmission owners in developing detailed plans of service for commercially viable transmission projects and to establish the basis for regulatory approvals of specific transmission projects. Phase 1 has been sub-divided into two tasks, with Phase 1A defining the resource assessment methodology, detailing study assumptions, and identifying resources to be considered in the project-level analysis (this report). Phase 1B will utilize this methodology to aggregate the identified renewable energy resources into Competitive Renewable Energy Zones (or "CREZ").

1.2 Stakeholder Collaboration

RETI is a multi-stakeholder collaborative process involving a broad range of participants, including utilities, generators, regulatory agencies, public interest and environmental groups. A collaborative process is crucial to developing consensus support for specific plans for renewable energy and related transmission development. The RETI organization includes two permanent committees, and creates ad hoc committees or working groups as necessary. For instance, the Stakeholder Steering Committee developed a Phase 1A Working Group to advise Black & Veatch on the development of methodologies and assumptions in Phase 1A. For Phase 1B, an Environmental Working Group has been formed to assist with environmental screens for resource assessment and to develop an environmental ranking construct.

Deleted: Committees

Deleted: Committees

1.3 RETI Study Area

The objectives of RETI are to identify renewable resources in California and adjoining areas that can deliver energy to California to meet its RPS requirements, and to identify the transmission necessary to deliver this energy. The RETI study region, depicted in Figure 1-1, includes California, Arizona, Nevada, Oregon, Washington, British Columbia, and the northern part of Baja California.

Reports to identify potentially opportune renewable energy projects. Similarly, a recent study conducted by AWS Truewind for the California Energy Commission's Intermittency Analysis Project is used as a first screen for identification of 100+ potential wind projects. Adding to this body of information, Black & Veatch incorporates its knowledge of resource technologies, costs and performance to update and augment available information. Finally, Black & Veatch works to ensure consistency in assumptions and approach so that all resources are evaluated against common metrics without bias. Throughout this process stakeholders are engaged to provide input on assumptions, methodologies and results.

Deleted: will be

Deleted: will work

Deleted: will be

Many of the potential renewable resources in the RETI study area are located in common areas and would be attached to the transmission system at a common interconnection point. These aggregations of resource are called Competitive Renewable Energy Zones. CREZs are ranked by their cost-effectiveness based on their developable potential, taking into account environmental concerns, the quality of the resources, the cost to develop those resources, and the cost of transmission needed to deliver those resources to load centers.

Deleted: (CREZs)

Figure 1-2 gives a graphical overview of the RETI Phase I methodology. Key aspects of this methodology are discussed in more detail below.

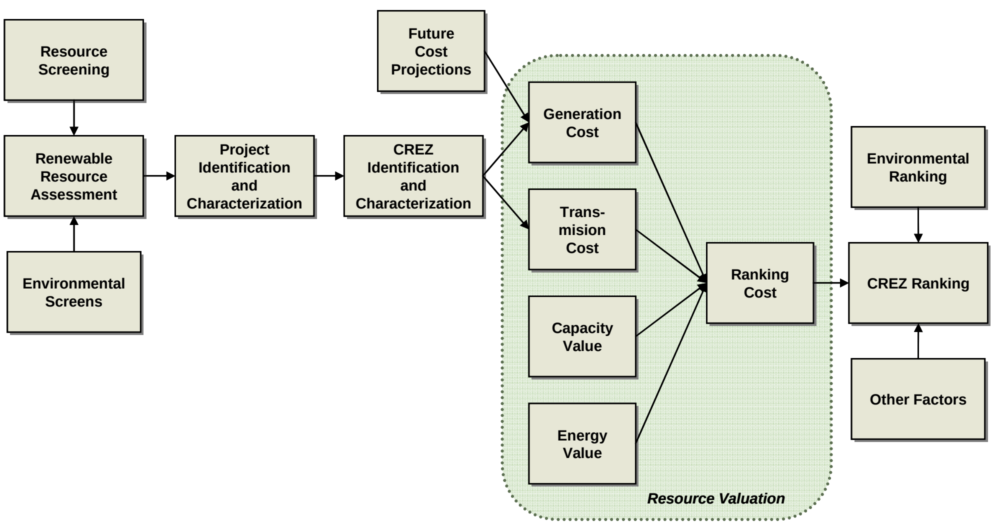


Figure 1-2. Overview of RETI Phase I Methodology.

Resource Assessment and Project Identification - RETI assesses the potential for the development of renewable technologies in the study area. After a high-level

Deleted: will assess

screening in Phase 1A, a more detailed resource assessment will be performed to identify potential projects. This resource assessment will include a set of detailed environmental screens to be developed by the Environmental Working Group in Phase 1B. Projects will be characterized based on the cost, performance, and environmental assumptions for each technology. To the extent possible, RETI will use information about actual projects in this analysis. Where those projects are not sufficient to exploit the identified resource, RETI will use generic information to develop additional hypothetical, but realistic, projects.

Resource Valuation – The economics of identified projects will be evaluated using the resource valuation methodology. This methodology allows disparate technologies and projects to be considered on a consistent basis. Resource valuation takes into account the busbar cost of generation as well as the transmission cost. RETI will not include transmission integration costs. The methodology then subtracts the energy and capacity value of the project, based on the generation profile. RETI will develop supply curves consisting of the many projects identified in the assessment. This will be used to compare projects in an economically rational fashion. This assessment is in addition to environmental and other assessments.

CREZ Identification and Characterization – Renewable resources will be aggregated into CREZs based on their transmission requirements, economics, and resource characteristics. CREZs may then be ranked to determine the priority for transmission development. The methodology used to design and rank CREZs includes such factors as cost, the ability of the CREZ to contribute to meeting the RPS requirements, resource development time-frame and environmental impacts.

Environmental Assessment and Ranking. In Phase 1B the Environmental Working Group will develop environmental criteria to include in the CREZ ranking process. This will allow environmental impacts to be assessed similar to the resource valuation process used for economic ranking.

Transmission Development – RETI will identify transmission availability, criteria for transmission additions, and estimate the costs of new transmission. RETI will use public information, such as the California utilities' Transmission Ranking Cost Report (TRCR) data and proposed transmission line information as a basis for developing transmission costs, where possible. Where public information is not available, RETI will use transmission cost information developed by Black & Veatch.

1.5 Assumptions

The RETI analysis incorporates a wide variety of assumptions including renewable demand and current generation and transmission system information, resource

Deleted: and

Deleted:

Deleted: **Transmission Development** – RETI will identify transmission availability, criteria for transmission additions, and estimate the costs of new transmission. RETI will use public information, such as the California utilities' Transmission Cost

Formatted: Font: Bold

operating and cost assumptions, and economic assumptions. RETI Phase 1 assumptions were developed over the course of several meetings with the Phase 1A Working Group.

The assumptions included in this Phase 1A report are Black & Veatch's best assumptions at the time of publication. Refinement of both the accuracy and precision of these assumptions will continue through Phase 1B.

A key assumption was developing the "base case" or the group of generating and transmission resources the RETI process includes as the starting point for the analysis. For generation resources, this includes:

- Operating renewable generation resources
- Renewable projects currently under construction
- Renewable projects in pre-construction that have all three of the following: a contract for energy sales, all major siting and construction permits and a transmission interconnection agreement

Deleted: ;

Deleted: ; and

Deleted: .

For transmission resources, the base case includes:

- Existing transmission
- Transmission projects under construction
- Transmission projects approved by the transmission control operator

Black & Veatch has developed representative cost and performance assumptions for all the major renewable energy resource types. These will be used as a general starting point for developing site-specific project characteristics in Phase 1B. These typical technology assumptions are shown in Table 1-1, with the levelized cost of generation shown in Figure 1-3. While the cost ranges shown in Figure 1-3 are very broad, Phase 1B will develop more specific estimates for each renewable energy project location or resource class (for out-of-state resources). It is important to note that the levelized cost of generation is only one component of the resource valuation process. The others include transmission cost, energy value, and capacity value.

Field Code Changed

Field Code Changed

Table 1-1. Renewable Technologies Performance and Cost Summary.

	Net Plant Capacity, MW	Net Plant Heat Rate, Btu/kWh	Capacity Factor	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Fuel Cost, $/MBtu	Levelized Cost, $/MWh
Solid Biomass	35	14k to 17.5k	80	3000 to 4500	83	11	0 to 3	67 to 140
Cofired Biomass	35	10000	85	300 to 500	5 to 15		-0.5 to 1	-1 to 22
An. Digestion	0.15	13000	80	4000 to 6000		17	1 to 3	100 to 168
Landfill Gas	5	13500	80	1200 to 2000		17	1 to 2	50 to 80
Solar Thermal	200		26 to 29	3800 to 4800	66			143 to 192
Solar Photovoltaic	20		25 to 30	6500 to 7500	35			201 to 276
New Hydroelectric	<50		40 to 60	2500 to 4000	5 to 25	5 to 6		57 to 136
Inc. Hydroelectric	1 to 600		40 to 60	600 to 3000	5 to 25	3.5 to 6		10 to 98
Wind	100		25 to 40	1900 to 2400	50			59 to 128
Offshore Wind	200		35 to 45	5000 to 6000	75-100			142 to 232
Geothermal	30		70 to 90	3000 to 5000		25 to 30		54 to 107
Marine Current	100		25 to 45	2200 to 4725	90 to 255			97 to 410
Wave	100		25 to 45	2800 to 5200	150 to 270	11		135 to 445

Notes:

Levelized cost is the levelized cost of generation only. Includes applicable incentives, subsidies, etc.

Break-outs for fixed and variable are arbitrary and not consistent across technologies. When no value is shown for one O&M category, it is assumed that the other O&M category includes all O&M costs.

Deleted: 14500

Deleted: 5000

Deleted: 150

Deleted: -

Deleted: 3600

Deleted: 4200

Deleted: 137

Deleted: 176

Deleted: -

Deleted: Cost includes

1.6 Resource and Technology Recommendations

A comprehensive resource and technology review was conducted to assess the technical potential for various types of renewables (e.g. solar, wind, biomass) in the RETI study region. Resource and technology evaluation were conducted for the ten resource types listed in Table 1-2 and Table 1-3. The tables shows the raw technical potential for each resource across the RETI study region.

Table 1-2. Renewable Energy Technical Potential in RETI Study Region (MW).

	AZ	Baja	BC	CA	NV	OR	WA	Total
Biomass	180	N/A	2,560	4,160	42	425	1,615	8,982
Anaerobic Dig.	18	N/A	60	293	N/A	13	203	587
Landfill Gas	10	N/A	22	139	6	23	17	217
Solar Thermal	313,628	N/A	N/A	439,948	236,989	N/A	N/A	990,565
Solar PV	N/A	N/A	N/A	*17 million*	N/A	N/A	N/A	*17 million*
Hydro	N/A	N/A	304	159	N/A	N/A	133	596
Wind	2,553	1,800	4,790	21,099	6,178	7,226	9,544	53,190
Geothermal	50	80	610	2,375	1,488	380	50	5,033
Wave	N/A	N/A	14,060	8,166	N/A	3,523	2,850	28,599
Marine Current	N/A	N/A	1,436	86	N/A	N/A	36	1,558

Sources: see individual report sections

Notes:

The estimates of technical potential are based on the following constraints, described in the Resource Screening section of the report. Additional qualifications include:

- Anaerobic Dig. Higher range of estimates shown.
- Solar Thermal Class 2 and higher, slope < 1 percent. Western Arizona, and southern Nevada.
- Solar PV Only California resources
- Hydro Projects >10 MW
- Wind Class 4 and higher resources
- Wave Primary sites, rated capacity

Deleted: table also

Field Code Changed

Deleted: .

Deleted: 8-

Deleted: 85-

Deleted: 0

Deleted: 10-

Deleted: 18-

Deleted: 181-

Deleted: 316

Deleted: 0

Deleted: 443,799

Deleted: 172,181

Deleted: 0

Deleted: 0

Deleted: 932,608

Deleted: 0

Deleted: 0

Deleted: 162

Deleted: 231

Deleted: 0

Deleted: 66

Deleted: 244

Deleted: 703

Deleted: 0

Deleted: 760

Deleted: 0

Deleted: 15,299

Deleted: 2,114

Deleted: 1

Deleted: resources

Deleted: and <30 MW

Table 1-3. Renewable Energy Technical Potential in RETI Study Region (GWh/yr).

	AZ	Baja	BC	CA	NV	OR	WA	Total
Biomass	1,261	N/A	17,940	29,153	294	2,978	11,318	62,945
Anaerobic Dig.	126	N/A	420	2,053	N/A	91	1,422	3,693
Landfill Gas	70	N/A	154	974	42	161	119	1,521
Solar Thermal	756 k	N/A	N/A	1,059 k	571 k	N/A	N/A	2.4 M
Solar PV	N/A	N/A	N/A	41 M	N/A	N/A	N/A	41 M
Hydro	N/A	N/A	1,332	696	N/A	N/A	583	2,610
Wind	7,268	5,124	102,623	60,068	17,589	20,572	27,172	240,417
Geothermal	350	561	4,275	16,644	10,428	2,663	350	35,271
Wave	N/A	N/A	43,107	25,037	0	10,802	8,738	87,685
Marine Current	N/A	N/A	4,402	264	N/A	N/A	110	4,776

Sources: see individual report sections

Notes:

The estimates of technical potential are based on the following constraints, described in the Resource Screening section of the report. Additional qualifications include:

- Anaerobic Dig. Higher range of estimates shown.
- Solar Thermal Class 2 and higher, slope < 1 percent. Western Arizona, and southern Nevada.
- Solar PV Only California resources
- Hydro Projects >10 MW
- Wind Class 4 and higher resources
- Wave Primary sites, rated capacity

Based on the resource and technology assessments performed, Black & Veatch has developed a set of recommendations for which resources should be considered in Phase 1B. The determination of whether to include a resource and technology in Phase 1B was based on several factors including: likely ability of the resource to contribute to California RPS requirements due total resource potential, ability to cost-effectively deliver the resource to the California grid, and technology maturity. Based on these assessments, resources with limited potential to provide energy to California are eliminated from further detailed review in Phase 1B. While there may be discrete resources in these regions that might provide energy to California, there are not sufficient resources in these areas to merit exploring potential new transmission to access these resources.

Each resource is discussed in more detail below.

Biomass – resources were identified in all states and regions, with California and the Pacific Northwest having substantial biomass resource potential. Based on the potential to meaningfully contribute to California's requirements, RETI recommends that

Deleted: as to the

Deleted: that

Deleted: -

biomass resources in California, Oregon, Washington and British Columbia are considered further in the Phase 1B analysis.

Anaerobic Digestion – resources were identified in most areas, though the quantity was limited. Due to the small size and distributed nature of these resources, Black & Veatch does not recommend including anaerobic digestion resources in the Phase 1B analysis.

Landfill Gas – There is limited resource potential for landfill gas to meet the RPS requirements. Similar to anaerobic digestion, due to the small size and distributed nature of these resources, Black & Veatch does not recommend including these resources in the Phase 1B analysis.

Solar Thermal – The solar thermal resource is limited to the Southwest U.S. The resource assessment revealed substantial quantities of developable solar thermal resource. Black & Veatch recommends that solar thermal in California, southern Nevada and western Arizona be included in the Phase 1B analysis.

Solar Photovoltaic – Solar photovoltaic (PV) is unique among renewable technologies, as it can be located almost anywhere, and scaled to virtually any size. RETI Phase 1A identified a virtually unlimited amount of PV potential. For Phase 1B, Black & Veatch recommends incorporating only solar PV located in California as there is sufficient high-quality resource within in California to meet almost any level of demand. However, to the extent that developers provide information on specific projects located out-of-state with planned delivery to California, these will be included in the RETI analysis.

Hydro – the Phase 1A analysis determined there is several hundred MW of potential small-scale (≥10 MW) hydro generation available in California, Washington and British Columbia. The sites identified are those with the fewest environmental concerns. This potential is small compared with other resources assessed. Black & Veatch recommends that the small hydro resources not be considered in detail in the Phase 1B analysis. Hydro development's contribution to the RPS will be handled in aggregate.

Wind – Wind resources were identified in all areas, though the quality of the resource differs widely. Based on the wind quality and accessibility, Black & Veatch recommends that wind be included from all regions except Arizona and northern Nevada. However, to the extent that developers provide information on specific projects located out-of-state with planned delivery to California, these will be included in the RETI analysis.

Geothermal – the Phase 1A analysis determined there is substantial geothermal development potential in California, Oregon, Nevada and British Columbia, with limited

Deleted: -

Formatted: Font: Not Bold

Deleted:

Formatted: Font: Bold

Deleted: -30

Deleted: Oregon,

Deleted: is

Deleted: cost-effective and reliable generation that can provide substantial amounts of energy

Deleted: identified between 10-30 MW be included in the

Formatted: Font: Not Bold

Deleted: -

Formatted: Font: Bold

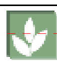
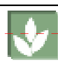
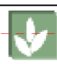
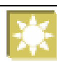
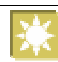
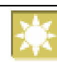
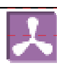
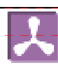
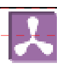
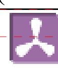
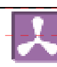
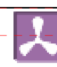
amounts elsewhere. Like hydro, geothermal has the potential to provide substantial amounts of energy. Black & Veatch recommends that geothermal located in California, Oregon, Nevada and British Columbia should be included in the Phase 1B analysis.

Wave and Marine Current – These technologies offer substantial technical potential but are unlikely to achieve a commercial level of development sufficient to contribute to California's RPS goals within the planning horizon. Black & Veatch recommends that these technologies not be brought into the Phase 1B analysis, but should be monitored for potential future inclusion in the RETI analysis.

The only Baja California resource recommended for inclusion in Phase 1B analysis is wind. There is limited information regarding the resource potential in Mexico, but it is unlikely there will be significant renewable development for export, as there are no financial incentives for renewable energy development in Mexico and there is limited transmission between Mexico and California.

Table 1-4 identifies resources that are recommended for consideration in Phase 1B.

Table 1-4. Resource Recommendations for Phase 1B.

	CA	OR	WA	NV	AZ	Baja California	British Columbia
Solid Biomass							
Solar Photovoltaic							
Solar Thermal				 (south)	 (west)		
Onshore Wind				 (south)		 (north)	
Geothermal							

Deleted: , Mexico area

Deleted: , MX

Deleted: , CA

Formatted Table

Deleted: Small Hydro ... [1]

Formatted Table

1.7 Phase 1B Scope of Work

Phase 1B of RETI is designed to implement the methodology developed in Phase 1A, as described in this document. The proposed Black & Veatch draft scope of work for Phase 1B is included as Appendix A to this report.

Deleted: DRAFT Scope

Deleted: Work

In addition to the scope of work outlined in Appendix A, many other activities are expected to occur in parallel to Black & Veatch's work in Phase 1B. Most importantly, the Environmental Working Group will be developing significant data, methodological proposals, and other processes that will need to be integrated into the overall RETI process.

2.0 Introduction

The California Renewable Energy Transmission Initiative (RETI) is intended to bring together all stakeholders in renewable transmission and generation to participate in a process to identify, plan, and establish a rigorous analytical basis to inform planning and permitting for the next major transmission projects needed to access renewable resources in California and adjacent areas. The goal of RETI is to identify and quantify the renewable resources that may provide cost effective and environmentally sensitive energy to meet the California Renewable Portfolio Standard (RPS) and then identify the transmission requirements to access and deliver these resources to the California electric grid.

The overall RETI project is divided into three discrete phases. Phase 1 is designed to provide an initial identification and ranking of potential renewable resource zones and to broadly identify transmission requirements to access these zones. Black & Veatch has been retained to conduct the Phase 1 analysis on behalf of the RETI Stakeholder Steering Committee (SSC). Phase 2 will examine generation and transmission in more detail and will develop conceptual transmission plans to the highest-ranking zones. Phase 3 is intended to support transmission owners in developing detailed plans of service for commercially viable transmission projects and to establish the basis for regulatory approvals of specific transmission projects.

Phase 1 has been sub-divided into 2 tasks, with Phase 1A defining the study methodology, detailing study assumptions, and identifying resources to be considered in the analysis. Phase 1B will utilize this methodology to aggregate the identified renewable energy resources into Competitive Renewable Energy Zones (or "CREZ"). A CREZ is defined as a group of renewable projects that are electrically associated that, when combined, have improved economics over individual resources.

Black & Veatch is pleased to provide to the SSC this report on RETI Phase 1A activities. This report is designed to describe to the RETI SSC the methodology, assumptions and resource information to be used in Phase 1B of the project.

This work was performed under contract with the University of California, Office of the President – California Institute for Energy and the Environment.

2.1 Background

California has adopted a Renewable Portfolio Standard requiring that 20 percent of electric energy be generated from renewable resources by 2010 (2013 with flexible

Deleted: (RPS)

compliance),[3] and may soon require that investor owned utilities meet 33 percent of their needs with renewables by 2020 in order to meet the green house gas emission reduction requirements of AB 32.[4] Meeting these RPS goals will require a substantial amount of new transmission development, as most renewable resource areas are located in remote areas rather than near the state's major load centers. Without proactive transmission planning guided by an economic and environmental analysis of developable potential, it is difficult to know which resource areas are the most economically and environmentally viable, which areas should be priorities for development, and the scale of required transmission. Transmission is costly and difficult to permit, and it has a longer development horizon than most renewable generation development. Furthermore, transmission investments typically require large expenditures at the outset of the renewable development cycle. Foresight is required in the planning of transmission development for the purpose of exploiting renewable resources. If economically inefficient resources are targeted for development, then California may burden ratepayers with "stranded costs" to connect transmission to sub-par resources. Further, if a piecemeal approach is taken to develop transmission to individual resources, than the opportunity to develop a cost efficient, all-inclusive integrated transmission plan may be lost.

Deleted: -

The Renewable Energy Transmission Initiative (RETI) is a statewide initiative designed to identify the transmission investments necessary for California to achieve its renewable energy goals in the most cost-effective and environmentally sensitive manner possible. RETI is intended to inform and support California renewable policy-making, regulatory activities, and planning processes. It supports, rather than supplants, existing processes, including:

- California Independent System Operator's (CAISO) interconnection reform efforts and transmission planning process, including any modifications to that planning process resulting from compliance with Order No. 890 of the Federal Energy Regulatory Commission
- California Energy Commission (CEC) energy policy development, transmission corridor designation, and power plant siting to help facilitate and

[3] SB 1078 established an RPS of 20% by 2017. The Energy Action Plan, adopted by the Commission and the California Energy Commission (CEC) in May 2003, accelerated the completion date to 2010. SB 107, passed in 2006, codified that policy.

[4] Assembly Bill 32, Ch. 488, Stats. 2006. Executive Order S-3-05, signed by the Governor on June 1, 2005, establishes greenhouse gas emission reduction goals for California and identifies acceleration of the renewable energy goals to 33% of energy sales by 2020 as one strategy to meet those goals. See "Strategies Underway in California That Reduce

coordinate the planning and permitting of renewable generation and minimize duplication of efforts

- California Public Utility Commission (CPUC) renewable resource and transmission proposal proceedings
- Publicly owned utility resource and transmission planning processes

Deleted: -

Additional background information on the RETI process including frequently asked questions is available on the CEC web page at www.energy.ca.gov/reti.

2.2 RETI Organization

RETI is a multi-stakeholder collaborative process involving a broad range of participants, including utilities, generators, regulatory agencies, federal land use management agencies, and public interest and environmental groups. A collaborative process is crucial to developing consensus support for specific plans for renewable energy and related transmission development. The RETI organization includes three permanent Committees/Groups, and creates ad hoc Work Groups as necessary. For instance, the Stakeholder Steering Committee developed the Phase 1A Working Group to advise Black & Veatch on the development of methodologies and assumptions in Phase 1A. For Phase 1B, an Environmental Working Group has been formed to assist with environmental screens for resource assessment and to develop an environmental ranking construct.

2.2.1 Coordinating Committee

The RETI effort is supervised by a Coordinating Committee comprised of California entities responsible for ensuring the implementation of the state's renewable energy policies and development of electric infrastructure, including:

- California Public Utilities Commission
- California Energy Commission
- California Independent System Operator
- Three Publicly Owned Utility Organizations - (SCPPA, SMUD, and NCPA)

Deleted: -

2.2.2 Stakeholder Steering Committee

The RETI Stakeholder Steering Committee (SSC) was established to support and guide the work of RETI on behalf of all stakeholders. The SSC has approximately 30 members, representing a wide range of interests including transmission owners, load

Greenhouse Gas Emissions" at http://www.climatechange.ca.gov/climate_action_team/factsheets/2005-

serving entities, renewable generation developers, environmental groups, state and federal permitting agencies and others that will be impacted by the development of renewable resource and transmission in California.

A kickoff presentation for the Black & Veatch Phase 1A scope of work was made to the SSC on January 22, 2008. A progress report was provided to the SSC on February 27, and a presentation of the Phase 1A report was made to the SSC on March 19.

2.2.3 Plenary Stakeholder Group

The RETI Plenary Stakeholder Group (PSG) includes all participants and interested parties, and is assembled once every 2-3 months to review RETI progress and to provide input and advice to the SSC and its Working Groups. The PSG is tasked with reviewing the work of the SSC to ensure its views are represented. A kickoff presentation for the Black & Veatch Phase 1A scope of work was made to the PSG on January 22, 2008. A presentation of the Phase 1A report was made on March 26.

Deleted:

2.2.4 Phase 1A Working Group

The RETI SSC established an ad hoc 11-member Phase 1A Working Group to work with Black & Veatch on the RETI methodology and assumptions discussed in this report. Meeting weekly, the Phase 1A Working Group has provided valuable input into the process. Presentation materials for these meetings are available on the RETI website. The Phase 1A Working Group input and recommendations are reflected in the methodology and assumptions detailed in this report. The members of the Phase 1A Working Group included:

- Gary Allen – Southern California Edison
- Rainer Aringhoff – Solar Developers (Deleted: -)
- Joe Bertotti – Regional Council of Rural Counties
- Linda Brown – San Diego Gas & Electric
- Mike DeAngelis – Sacramento Municipal Utility District (Deleted: ,)
- Anne Gillette - CPUC
- Steven Kelly – Independent Energy Producers
- Clare Laufenberg – CEC
- John McCaull – Geothermal Developers
- Gregg Morris – Biomass Developers (Deleted: Greg)
- Dariush Shirmohammadi – Wind Developers

06_GHG_STRATEGIES_FS.PDF

The valuable contributions of these volunteers are greatly appreciated.

2.3 Objective

The overarching objective of RETI is to provide information to policymakers and stakeholders on the transmission requirements to access cost-effective, environmentally sensitive renewable resources. This study takes the broadest possible perspective, attempting to integrate many different sources into a single study to develop a clear picture of a California renewable development pathway. The existing knowledge base creates a very strong foundation for this process.

RETI Phase 1 involves a thorough assessment of the renewable resources in California and adjoining regions, resulting in the identification of those areas, called Competitive Renewable Energy Zones, which have the potential to offer California the most cost-effective, environmentally sensitive renewable energy development. Phase 1 also estimates the transmission costs associated with delivering these resources to the electric grid and California energy consumers. CREZs are then ranked by their cost-effectiveness and environmental attributes, based on the renewable resource supply curves and the transmission costs to access each CREZ.

Deleted: (CREZs)

2.4 Approach

Black & Veatch has developed a bottom-up approach to achieving RETI's Phase 1 objectives. Black & Veatch's work involves the identification and thorough assessment of the renewable resources available to California and neighboring areas, including an assessment of the costs to develop those resources and deliver the energy to load centers.

To the extent possible and practical, this work incorporates the great body of work that has already been performed to assess renewable energy development potential in the RETI study region. This analysis brings together many previously disparate pieces of information. For example, renewable energy potential assessments are combined with information from the utility Transmission Ranking Cost Reports to identify potentially opportune renewable energy projects. Additionally, recent work by AWS Truewind for the CEC's Intermittency Analysis Project is used as a first screen for identification of 100+ potential wind projects. Adding to this body of information, Black & Veatch incorporates its knowledge of resource technologies, costs and performance to update and augment available information. Finally, Black & Veatch will work to ensure consistency in assumptions and approach so that all resources are evaluated against common metrics without bias.

Deleted: of study

2.6 Report Organization

The purpose of this Phase 1A report is to detail the assumptions and methodology Black & Veatch will use in Phase 1B of the RETI analysis. This report also presents a general overview of renewable energy technologies under consideration and concludes with a high-level screening of renewable resource opportunities in the RETI study region. Following this Introduction, this report is organized into the following sections:

Deleted: of study

- Section 3 – Methodology. This section describes the methodologies that Black & Veatch will use in the Phase 1 analysis. The section begins with a general overview of the key steps in the methodology. The remaining sections examine these steps in greater detail.
- Section 4 – Assumptions. This section documents the RETI Phase 1 general assumptions. This includes a discussion of the economic assumptions that apply to all new renewable projects, the financial incentives available for projects, and the RPS requirements to be met.
- Section 5 – Technology Characterization. This section discusses the renewable energy technologies considered by the RETI analysis. Each discussion includes a description of the technology and an outline of the cost and performance assumptions used to model it in the analysis.
- Section 6 – Resource Screening. This section evaluates the resource for each renewable energy technology. In each case, an assessment is made of the total technical potential for the technology over the RETI study region, and the total resource is then screened for technical and environmental viability. Ultimately, recommendations are developed for each technology regarding recommended resource areas for further analysis.
- Section 7 – Phase 1B Scope of Work. Introduces the draft scope of work for Phase 1B

Formatted: Font: Not Bold
Formatted: Font: Not Bold
Formatted: Font: Not Bold
Formatted: Font: Not Bold
Formatted: Font: Not Bold
Formatted: Font: Not Bold
Formatted: Font: Not Bold

2.7 Changes from Draft Report

This final draft report contains numerous changes since the draft report issued on March 14, 2008. Black & Veatch thanks all the RETI stakeholders who provided comments on the draft report. Some of the substantive changes include the following.

- The treatment of resources outside of California is clarified

- The importance of environmental considerations and the role of the environmental working group are emphasized
- The importance of considering uncertainty in the resource valuation process has been acknowledged
- Several assumptions about solid biomass technology are revised
- Several assumptions about solar thermal technology are revised
- The assessment of the wind resource in British Columbia is revised
- The assessment of the wave resource in British Columbia is revised
- The assessment of hydroelectric resources throughout the RETI study region is revised and hydroelectric resources are no longer recommended for detailed study in Phase 1B
- The draft Phase 1B scope of work has been revised to reflect the relevant changes

3.0 Methodology

RETI Phase 1 involves a thorough assessment of the renewable resources in California and adjoining regions, resulting in the identification of those areas, called Competitive Renewable Energy Zones (CREZs), which hold the greatest potential for cost-effective and environmentally conscious renewable energy development. CREZs are ranked by their cost-effectiveness and environmental characteristics. CREZ ranking takes into account environmental concerns, the quality of the resources in the CREZ, the cost to develop those resources, and the preliminary, high level estimates of the cost to develop the transmission needed to deliver those resources to load centers. RETI Phase 2 will develop conceptual transmission plans for those CREZs identified as priorities in Phase 1, and include a more detailed examination of the cost effectiveness of resource procurement and transmission development for a particular CREZ as compared to other projects or resources.

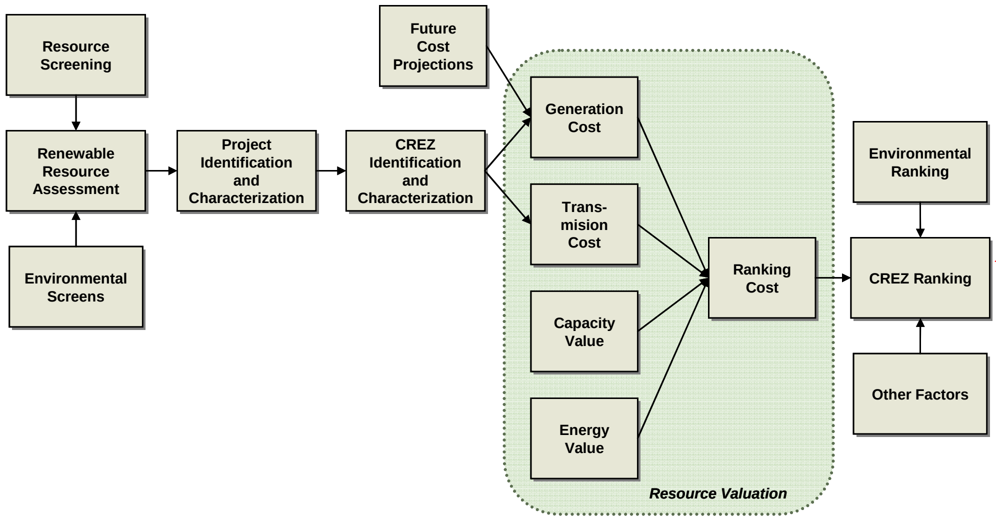
Deleted: based on developable potential

Deleted: high level

This section describes the methodologies that Black & Veatch will use in the Phase 1 analysis. The section begins with a general overview of the key steps in the methodology. The remaining sections examine these steps in greater detail.

3.1 RETI Phase 1 Methodology Overview

The RETI methodology is not a single algorithm; rather it is a series of analytical processes and steps that will culminate in the development of CREZs. Figure 3-1 provides a high-level overview of the RETI methodology.



Formatted: Keep with next

Figure 3-1. Overview of RETI Phase 1 Methodology.

The major steps in the Phase 1 methodology are briefly introduced below and then described further in the remainder of this section.

- **Base Case Definition** – Fundamental to the RETI analysis is the characterization of existing generation and transmission resources. California's RPS has existed for several years, and many projects and initiatives to develop renewables are underway. RETI will consider this existing development and use it as a starting point.
- **Resource Assessment and Project Identification** – RETI will assess the potential for the development of renewable technologies in the study area. After a high-level screening in Phase 1A, a more detailed resource assessment will be performed to identify potential projects. Detailed environmental overlays will be used to help identify lands with the greatest potential for development. To the extent possible, RETI will use information about actual projects in this analysis. Where those projects are not sufficient to exploit the identified resource, RETI will use generic information to develop additional hypothetical, but realistic, projects.

meet these requirements. Many of the newly contracted resources are located in areas requiring substantial transmission development and they will be unable to deliver their expected (and contracted) energy without this transmission. Additionally, increasing costs for power project development and technical problems with commercializing some renewable technologies may impact the ability of some executed contracts to deliver energy. The RETI base case must balance between respecting the commercial contracts for new renewable resources that have been executed and recognizing the reality that some portion of these contracts may never be fulfilled. If RETI overestimates the amount of renewable generation required, it may result in an overbuilding of the transmission system, leading to stranded costs. On the other hand, if RETI assumes more resources will be constructed than will likely happen, it will underestimate California's future resource and transmission needs.

Similarly, an accurate characterization of the transmission system is required. The current western transmission system is highly utilized, and RETI must make assumptions regarding current and future transmission availability to assess the cost and practicality of adding resources at different points on the transmission grid.

In developing its base case, RETI assumes that all existing renewable generating resources remain in operation at their current capacity through 2020. The base case also assumes that highly probable renewable resources and transmission additions will be constructed. These assumptions are detailed below.

3.2.1 Renewable Generation Projects

The RETI base case includes existing renewable resources and those projects with a high probability of coming on-line on schedule. Identifying which resources are "high probability" is problematic, however, as there are a variety of metrics that could potentially be used to identify these resources. Criteria such as economic viability of the project (is there a Power Purchase Agreement at a high enough price to allow the project to be financed?), level of project development (does the developer control the proposed site?), access to transmission (can the project reasonably interconnect to existing transmission?), and technical feasibility all must be considered. Projects included in the base case will be assumed to exist throughout the study period and will not be studied for their economic or environmental feasibility.

Projects not included in the base case will be considered as "potential" resources. These projects will be reviewed, potentially grouped with other resources into cost-effective CREZs, and then ranked by their viability considering economic, environmental, and potentially other factors.

Deleted: economic

Black & Veatch discussed criteria for determining base case resources at length with the RETI Phase 1A Working Group. While there was not complete consensus on which renewable generation resources to include in the base case, the majority of the Phase 1A Working Group endorsed a proposal that the base case include the following renewable generation resources:

Deleted: consulted with the RETI Phase 1A Working Group to develop

Deleted: , which discussed this issue

- Operating renewable generation resources
- Renewable projects currently under construction
- Renewable projects in pre-construction that have all three of the following: a contract for energy sales, all major siting and construction permits and a transmission interconnection agreement

Deleted: ;

Deleted: ; and

Deleted: .

Below is a discussion of these and other renewable resource categories that were considered for the base case.

Operating Renewable Resources

California currently has approximately 6,500 MW of operating RPS-eligible renewable resources. While many of these resources have contracts that will expire within the planning horizon, or that may change or expand within the horizon, RETI anticipates these resources will continue to operate at their current level of output. Any additions to these resources will be considered as new incremental capacity. It is clear that operating resources should be included in the base case.

Existing non-hydro renewable resources are shown in Figure 3-2 and Table 3-1. There are nearly 11,000 MW of non-hydro renewable resources operating in the RETI study region. Wind and geothermal are the dominant resources, with over 8,000 MW between the two. Biomass has nearly 2,000 MW, with solar, landfill gas, and anaerobic digestion completing the picture. It should be noted that this number represents nameplate capacity and does not reflect the different capacity factors of the resources.

Deleted: of study

These resources are simply defined by location, not by power purchaser. For example, some of the renewable resources in Oregon and Washington are serving load in California. Further, some of the California resources export power to out-of-state purchasers.

Renewable Generation under Construction

Generation that is under construction has a very high probability of coming on line and is included in the base case. As shown in Table 3-2, as of March 14, 2008 there are 316 MW of renewable energy projects under construction in California.

Deleted: were

Table 3-2. Renewable Energy Projects Under Construction in California.

Plant Name	Owner	Technology	Capacity, MW
Kittyhawk	Envirepel Energy Inc	Biomass	2.2
Brawley Geothermal	Ormat Technologies Inc	Geothermal	50
Heber Geothermal	Heber Geothermal Co	Geothermal	10
Chiquita Canyon Landfill	Ameresco Inc	Landfill Gas	8
Keller Canyon Landfill	Ameresco Inc	Landfill Gas	3.8
Ox Mountain Landfill	Ameresco Inc	Landfill Gas	11.4
Alite Wind Farm	Allco Wind Energy	Wind	24
Dillon Wind	PPM Energy Inc	Wind	45
Pine Tree Wind	LADWP	Wind	120

Source: Black & Veatch query of Ventyx Energy Velocity database, March 13, 2008.

Renewable Generation with Approved and Pending PPAs

California public and investor owned utilities have aggressively procured renewable resources in the past several years, executing contracts for over 4,000 MW from existing and proposed resources since the enactment of the RPS requirement[5]. Whether to assume executed contracts as "existing" resources for base case purposes raises a number of issues. Utilities are depending on these contracts for RPS compliance, and securing an executed contract requires a substantial amount of project development time and energy. Further, an executed contract indicates the resource may have commercial viability. That said, historically, not all executed contracts will result in on-line generation, and recent experience indicates many projects with PPAs are likely to be delayed, if not cancelled. Technical problems, inability to secure construction permits, and changing economics are just a few of the reasons why resources with a contract may not become operational.

Deleted: -

Deleted: generators

Deleted: new

Deleted: acquisition of

In modeling projects with PPAs, RETI will make the following assumptions:

[5] Renewables Portfolio Standard Quarterly Report, CPUC, January, 2008. http://www.cpuc.ca.gov/NR/rdonlyres/F710CD37-3053-439C-B2A4-07CCB5D8B287/0/RPS_Rpt_to_Legislature_January_2008.DOC

Deleted: California IOU

Table 3-3. Proposed Projects with PPAs with California IOUs.

Technology	Minimum Contract MW		
	Approved	Pending Approval	Total
Biomass [a]	94	2	96
Geothermal [b]	245	170	415
Ocean	-	2	2
Small Hydro	1	-	1
Solar Thermal	1,452	177	1,629
Solar Photovoltaic	7	9	16
Wind [c]	525	2,022	2,547
Grand Total	2,324	2,381	4,705

Source: CPUC contract database.

This list includes facilities to be constructed or restarted/repowered. It does not include online facilities. All facilities are in California unless noted below.

Notes:

[a] One project (20 MW) is located in Oregon

[b] Two projects (160 MW) in Oregon, one project (30 MW) in Nevada

[c] One project (200 MW) is located in Northern Baja, Mexico.

Short-listed and MOU Resources

The contract process for resources is long, and California utilities are constantly procuring additional future renewable generation. California IOUs have been issuing annual RPS solicitations for several years and are expected to continue this practice. From these solicitations, utilities develop a "short-list" of resources they will pursue contracts with, though there is no certainty that executed contracts will be developed for each of these resources. Similarly, utilities have signed "Memorandum of Understanding" (or MOU) agreements with developers to participate in the development of renewable facilities, with the expectation these agreements will lead to contracts or ownership of resources in the future.

For purposes of Phase 1, RETI will consider these projects as "potential" resources, rather than included in the base case. Without a contract for the sale of energy, it is more unlikely these resources will be developed, and as noted above there is no certainty that a contract will result from a short-listed resource.

Proposed Resources without Utility Contracts

Many renewable developers have proposed generation projects without having a contract for the entire project output. Some of these resources may be short-listed in utility solicitations or may have an MOU for development, but no contract. The resources are at various level of development – some are purely theoretical and have no site, while others may be pursuing permits for construction and waiting in the CAISO queue. For purposes of Phase 1, RETI will consider these projects as "potential" resources, rather than included in the base case.

California Independent System Operator Queue Resources

Deleted: (CAISO)

As of January 25, 2008, the California ISO has received applications for transmission interconnection for over 42,000 MW of renewable generation. While this is meaningful evidence of renewable developer interest in California, an interconnection application at the CAISO provides little information regarding the degree of project development or project viability. Currently, anyone can submit an interconnection application to the CAISO by posting the $10,000 application fee and designating the interconnection point, technology, size of the generation unit, and other items. The CAISO has embarked on an application reform process to make the process more stringent to ensure that only projects with a high probability of development submit applications and/or remain in the queue.

Deleted: the

Deleted: and potential

Deleted: among

Confidentiality limits the amount and detail of information on interconnection applications available to RETI. The CAISO makes public general project location, interconnection point, potential MW, resource type, and on-line date, but does not provide more specific information to assess the viability of a project. Without access to additional information, it is not possible to determine, of the 42,000 MW, which resources are contracted, short-listed, or simply proposed. For this reason, RETI will use the information available in the queue as an indication of commercial interest in a general area, requiring further investigation in Phase 1B.

Table 3-4 shows the active ISO queue applications by technology. Figure 3-3 shows the applications on a map of California. Location of projects is shown as the point of interconnection, not the actual project location.

Bureau of Land Management (BLM) Land Applications

The California Desert District of the BLM has received hundreds of applications for developing solar and wind projects on BLM land. The applications total 66,000 MW on 1,800 square miles of land, far more capacity than is required to meet California's RPS requirement. As with queue resources, these applications reflect commercial interest in particular areas or technologies and will be addressed as such in the Phase 1 assessment.

In addition to the Desert District, applications in other BLM districts will also be reviewed. Black & Veatch will use the BLM's GeoCommunicator tool to identify the locations of potential projects.

Figure 3-4. BLM California Desert District (source: BLM).

Table 3-5. BLM Applications.

	Acres	MW
Solar Thermal	550,000	45,000
Solar Photovoltaic	130,000	11,500
Wind	480,000	9,700*
Total	1,160,000	66,200

Source: http://www.blm.gov/ca/st/en/fo/cdd/alternative_energy.html
Notes:
* This is assuming 50 acres per MW – most of these applications were for measurement Rights of Way that did not specify MW.
This does not include applications that were rejected.

3.2.2 Transmission Resources

The RETI Phase 1 base case will include the entire California high-voltage transmission system (defined as 230 kV and above), including both CAISO-controlled and publicly owned utility transmission facilities. The base case will also include lower-voltage transmission facilities required to access renewable resources, as well as that portion of the western U.S. high voltage transmission that may be required to allow California to import renewable resources from other states and areas. In Phase 1 the transmission analysis will be economic rather than technical. Phase 1 will identify the cost of interconnecting California resources to the grid and the cost of importing non-California renewable resource energy to California.

Deleted: -

Deleted: an

Transmission Additions in the Base Case

There are several transmission lines that have been proposed to increase transfer capability for new renewable generation in California and throughout the Western Interconnection. In California, some of these lines are within the CAISO control area, while others are proposed to be owned and operated by POUs. Outside of California there are several interstate transmission lines proposed for construction in the Western Interconnection to facilitate delivery of additional energy to California and the Southwestern U.S.

Consistent with the treatment of proposed renewable generation resources, the base case will include only high probability transmission additions. Determining which additions this should include is problematic, as the transmission planning, siting, approval, and construction process can easily span a decade from initiation to completion.

Black & Veatch consulted with the RETI Phase 1A Working Group to develop criteria for determining base case resources. The Phase 1A Working Group discussed this issue at length. While there was not complete consensus on additions to include, the final proposal made was that the base case include existing transmission, projects under construction and projects approved by the transmission control operator. Table 3-6 identifies transmission projects to be included in the CAISO control area. Black & Veatch will work with the POUs to determine if additional proposed transmission resources controlled by these entities should be included in the base case.

Table 3-6. New Transmission Included in the RETI Base Case

Line Name	Primary Owner	Location	In-Service Year
Tehachapi 1-3	SCE	Tehachapi	2009
Tehachapi 4-11	SCE	Tehachapi	2013
Sunrise Powerlink	SDG&E	Imperial Valley	2012
Devers – Palo Verde 2	SCE	LA Basin – Arizona	2012

3.3 Resource Assessment and Project Identification

RETI is assessing all renewable resources that will likely be employed to deliver renewable energy to California through 2020. This includes a range of technologies that are technically mature and commercially available, such as wind and solar photovoltaic, and emerging technologies such as marine current and wave technologies. The resource assessment is designed to determine which resources are appropriate for inclusion in the analysis, estimate the resource availability in terms of size, and assess the relative economic competitiveness and environmental suitability of the resources for each region in the analysis. Resources under consideration for this study include:

Deleted: project

- Biomass
- Biogas
- Solar
- Hydroelectric
- Wind
- Geothermal
- Marine current
- Wave

This section describes the approach to resource assessment, screening, and project identification.

Resource Assessment and Data Sources

RETI builds on the large and excellent foundation of existing studies and analyses from the CEC, the National Renewable Energy Laboratory (NREL), industry groups, universities, utilities, and other sources. Section 6 of this report identifies the data sources used for each renewable energy resource.

Many analyses have been performed on renewables in California and it is not the objective of RETI to simply duplicate or update past analyses. What differentiates RETI from the previous analyses is the broad view that RETI takes. RETI provides a detailed analysis of resource potential in the western North America, and with a much larger geographic perspective than previous work. This provides for consistent technical and economic assessment of resources and transmission using common assumptions and methodology, which hereto for has not been available to policy-makers, generators, utilities or others interested in renewable resource development. This provides RETI with the necessary information to identify and select the most cost-effective and environmentally sensitive CREZs.

Deleted: .

Deleted:

RETI will incorporate and expand upon the existing body of work to develop current characterizations of renewable resources and identify projects relevant to California today. Existing data sources contain a wealth of information and data, but it is important to recognize the limitations of previous analyses. Much of the information available in the public domain is now out-of-date. Costs have been increasing rapidly for a variety of factors. According to the Power Capital Costs Index developed by IHS Inc. and Cambridge Energy Research Associates, the cost of new power plant construction has increased 19 percent in the most recent 6 months, 27 percent over the past year, and 130 percent since 2000.[6]

The RETI work will also be additive in other respects:

- Many studies have just focused on the technical potential of renewables, while disregarding economic constraints to develop that potential. Other studies have focused either on a single resource (such as wind), on a single area (such as the Imperial Valley), or very specific issues (such as the intermittency of renewables). Finally, some important projects (such as the CEC's Strategic Value Analysis) do not consider potentially valuable resources, such as small hydro and wave energy. No single study has yet answered the question: "of all available resources through 2020, what renewables should be developed first, and where?"
- Most analyses assume a single fixed cost and performance per technology type (class 3 wind, flash geothermal, biomass, etc.). However, even within a resource category, there are wide variations in renewable projects that impact the cost of generation from any given project. The use of supply curves allows representation of the varying cost of renewables (see discussion near the end of this section, Supply Curve Development). Such models may demonstrate that renewable resources can have shallow supply curves, with the "lowest hanging fruit" developed first and more expensive resources developed later. Use of supply curves is particularly important for California given the relatively high 33 percent RPS target. For example, to assume that

[6] Power Engineering, "Power plant construction costs rise 27 percent", February 24, 2008.

all wind in the state has a capital cost of $1900/kW would likely underestimate actual costs for more remote and difficult to construction sites.

- Past work has generally not defined project-specific resources and costs. The resolution of many past estimates has at best been county-level or regional data (e.g., there is a total potential of 3500 MW of wind in Kern County). RETI will identify actual developable projects on a site-by-site basis in California. Outside of California, the resource assessment will be performed at a higher-level. Project specific performance and costs will be estimated. This is approach is necessary to develop meaningful supply curves and ultimately CREZs that reflect actual developable potential and realistic costs.
- Employing an Environmental Working Group composed of environmental advocates, power generators, regulators and other stakeholders, RETI will seek to develop a detailed map indicating environmentally sensitive areas, protected lands, endangered species habitat, and other valuable lands. This information, in GIS format, will be used as part of the resource assessment and project identification process. Collaborative development of such data to inform both generation and transmission siting has not been previously done across the RETI study region.

Deleted: .

Resource Screening

RETI includes consideration of resources, projects, and potential CREZs. Broadly, "resource" means renewable resource, such as solar, wind, biomass, etc. Projects are the individual proposed developments to use the resource. A "project" is an identified (or generic) development that has a specific capacity and location. A CREZ, described in detail in the CREZ Identification and Characterization section below, is a aggregation of projects that have cost economies by being combined. The relationship of the resource, project and CREZ is shown in Figure 3-5.

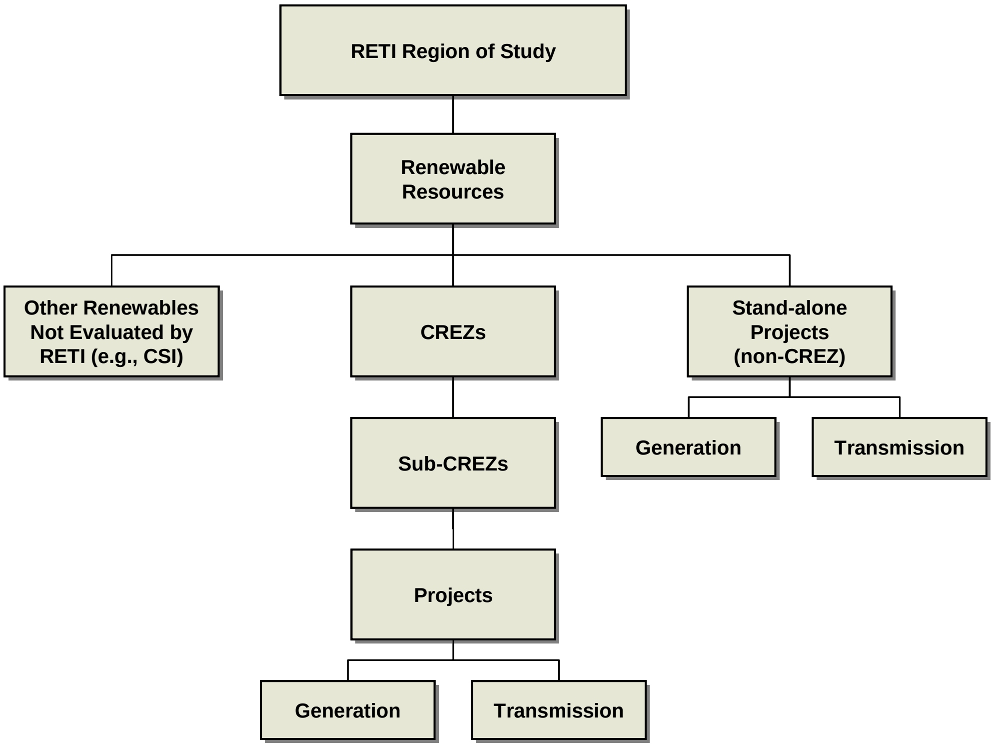


Figure 3-5. RETI Structure.

RETI starts with definition of the study region. This has been established to be California, Arizona, Nevada, Oregon, Washington, British Columbia, and the northern part of Baja California. Within this region there are numerous potential renewable resources that may be commercially viable. This Phase 1A report performs a high-level assessment and screening of those resources and regions. The objective of the high-level resource assessment is to identify the most promising renewable energy sources to meet California's RPS. This screening allows Phase 1B of RETI to focus its energy on higher priority opportunities. Several criteria are considered in the resource screening:

- Technical viability
- Commercial availability by 2020
- Economically competitive over the study time-frame
- Resource has significant potential to meet California RPS
- Resource is environmentally viable

As the focus of RETI is on the transmission requirements for renewable generation, RETI is not directly evaluating projects, opportunities, or customer-sited generation and distribution-level resource additions (<10 MW). RETI will include utility and CEC forecasts of these resources if available. This in no way makes a determination on the viability of these resources, and the RETI process accounts for the potential economic development of these resources to meet renewable goals.

As a result of the initial screening process in Phase 1A resources are placed into one of several categories:

- **Competitive Renewable Energy Zones.** Resources sufficiently concentrated to enable economic consideration of large-scale, shared transmission for these areas. These resource areas are often comprised of several potential projects with associated transmission. CREZs and sub-CREZs will be identified that group projects in various combinations. This process is discussed further in the CREZ Identification and Characterization section of this report. It is expected that this will constitute most of the resources and projects.
- **Stand-alone Projects (non-CREZs).** Resources that are isolated and which support the development of stand-alone projects. These projects are of sufficient scale to be considered in Phase 1B, but there are no additional regional resources that justify forming a CREZ.
- **Other Renewables Not Evaluated in Phase 1B.** These resources generally have limited potential to meet the California RPS, are smaller projects (<10 MW) that do not require transmission, or rely on technologies which are not fully commercial. An example is landfill gas, which has relatively limited potential and is typically less than 10 MW per project site. The aggregate generation potential of these resources is accounted for, but they are not directly considered as potential projects.

Deleted: Resources not evaluated
Formatted: Font: Bold
Deleted:

Section 6 of this report summarizes the resource screening carried out for Phase 1A. The resource assessment also serves the important role of providing fundamental data to identify and characterize renewable energy projects, as described further in the next section.

Project Identification and Characterization

Whether they are stand-alone or grouped as part of CREZs when possible, Phase 1B includes identification of specific projects including proposed and generic projects. When available, information on specific proposed projects will be used to the extent possible. If there appears to be resource potential for development in an area that is greater than the quantity of proposed defined projects, "generic" projects will be identified. Project characteristics will be estimated by Black & Veatch for each project including:

- Location
- Net plant output
- Capital costs
- Interconnection point
- Generation interconnection costs ("gen-tie")
- Fixed operation and maintenance
- Variable operation and maintenance
- Heat rate (if applicable)
- Fuel costs (if applicable)
- Incentives
- Capacity factor
- Generation profile
- Land use
- Water use
- Where possible, identification of the affected sensitive species, such as bird and bat populations, or endangered species (this will be done based on GIS-information developed by the Environmental Working Group and the proposed project location)
- Air emissions

Outside of California, specific project locations will not be identified, with some exceptions. The treatment of resources will generally be at a higher level, and resources will be categorized by class, rather than specific locations. For example: 2500 MW, southern Washington, Class 4 wind. The exceptions to this are (1) geothermal, which by its nature requires site-specific investigation, and (2) projects for which specific commercial interest has been demonstrated and information is provided to Black & Veatch for analysis.

Although out-of-state resources should be considered, RETI recognizes that other states have their own RPS requirements and goals and will require renewable generation to achieve this. Phase 1B will consider the effects of the local demand on resource availability. Black & Veatch anticipates coordinating the RETI program with the Western Governors Association's Western REZ initiative. This initiative is designed to develop a comparable analysis of resources and transmission throughout the WECC. The final results of the WREZ may not be available to RETI in the Phase 1 time frame, but RETI anticipates the results of this initiative will be included in future RETI phases.

In addition to local demand, the CAISO has indicated that there is limited available capacity on the CAISO bulk power system to import renewable energy from resources outside of California. Further, it is unlikely that significant new transmission transfer capability would be developed in the study period if the transmission resources are not currently under active development. The CAISO has proposed that total new capacity for renewables be limited to 2,500 MW from the Pacific Northwest (Oregon, Washington, British Columbia), and 2,500 MW from the Southwest (Arizona/Nevada). It is reasonable to incorporate the CAISO-proposed transfer limits for out-of state resources in the Phase 1 analysis.

Development Time-frame

Projects are assigned to one of three development time-frames:

- **Near-term: now to 2012.** These represent projects which can come online in time to meet the 2013 RPS target (assuming flexible compliance). It is expected that most of these projects are already under active development and are publicly known (for example, projects with approved PPAs). For projects with PPAs, the latest stated target on-line date will be used to establish the development time-frame.
- **Mid-term: 2013-2016.** These represent projects which will require more time to come on-line due to limited development thus far or timing of new transmission.
- **Long-term: 2017-2020.** These projects likely require significant new transmission with long planning lead times. This may also include some new projects which are expected to have longer than typical development and permitting periods (for example, new hydro).

Out of State Resources

While individual projects are modeled inside California, resources outside of the state are handled at a higher level. Rather than attempting to identify projects throughout the RETI study region, renewable resources outside of the state will be considered in aggregate. For example, a large area of class 4 wind may be identified in Oregon. In this case, a percentage of that potential is assumed developable in a given time-frame, and transmission costs are calculated to the center of the geographic area.

3.5 Environmental Considerations

Many of the renewable resources in the RETI study area are located in remote, environmentally sensitive areas. Phase 1 includes a "fatal flaw" environmental screening, with environmental impacts considered when evaluating generation and transmission resources. This environmental screening will focus on ensuring that resources and transmission are not located on protected or sensitive lands. Water and land impacts will also be assessed and, where possible, quantified. RETI will provide general environmental information for the siting of transmission and generation projects. This information is expected to be informative but not definitive -- any transmission or generation project that seeks to begin actual construction will still undergo, as part of existing permitting process, more targeted and thorough environmental impact review.

Deleted:

Deleted:

Deleted: ***Resource Areas***

3.5.1 Environmental Screening of Resources

Areas designated to be environmentally sensitive, such as federally designated wilderness and National Parks, were excluded from the resource assessment performed in Phase 1A. The full list of these exclusion zones was developed by NREL and is discussed in more detail in Section 6. By screening these areas from the Phase 1A analysis, their associated resources are considered undevelopable and are not included in RETI's initial resource assessment.

It is recognized that these high-levels screens are incomplete, and in Phase 1B, RETI will identify and assess potential resources in more detail. For this phase, a more comprehensive exclusion list will be developed that will include sensitive habitat areas, state parks, and other environmentally sensitive areas. The SSC has formed an Environmental Working Group (EWG) to develop these detailed screening criteria. The working group will take into account existing work from the CEC as well as input from a wide variety of environmental groups and other stakeholders.

Deleted: In

Deleted: RETI will form

Deleted: environmental working group

Black & Veatch will work with the EWG in the resource assessment portion of Phase 1B to:

- Identify detailed generation and transmission resource exclusion zones as applicable by technology. Maps will be prepared in GIS format. It is expected that the zones will include, but not be limited to: national/state parks, protected areas, culturally sensitive zones, high slope areas, some military lands, water, wetlands, urban areas, airports, sensitive habitats, etc.
- Identify appropriate water availability assumptions and technology application (i.e., wet vs. dry cooling)
- Identify a definition for sustainable biomass fuels to use in assessing biomass fuel availability

- Review appropriate emissions control technology and allowances/offsets for biomass
- Identify other environmental considerations relevant to generation and transmission siting, as advised by the Environmental Working Group

While RETI aims to provide valuable information about the environmental impact and feasibility of renewable generation and transmission within the study area, it will not perform an official state or federal environmental impact assessment. The RETI analysis produces outputs that may be used in such processes, but individual transmission and generation projects will still need to follow established environmental processes.

3.5.2 Environmental Metrics

RETI Phase 1 will provide important information regarding the impacts of the renewable development modeled in the analysis, including estimates of:

- General location of generation projects, and proximity to sensitive areas, habitats, etc.
- Where possible, identification of the affected sensitive species, such as bird and bat populations, or endangered species (this will be done based on GIS-information developed by the Environmental Working Group and the proposed project location)
- Land use for generation and transmission projects.
- Water use by generation projects
- Air emissions of generation projects

By producing estimates of these metrics, RETI will assist in understanding the cumulative environmental impact from the renewable development necessary to meet California's RPS requirements.

3.5.3 CREZ Environmental Ranking

In addition to the economic metrics that rank CREZs, RETI plans to include environmental factors in the ranking criteria. Such criteria for rating the environmental attributes of CREZs will be developed with input from the EWG. The criteria might take into account such factors as miles of new right of way required, impacts to sensitive habitats, water use, and other issues.

Deleted: environmental working group

California IOU Interconnection Points

Transmission availability and cost estimates are available for California transmission interconnection points owned by California IOUs. As part of the RPS procurement process, California IOUs are required to provide estimates of the Available Transfer Capacity (ATC) for grid interconnection points on their respective systems, as well as the estimated network upgrade costs to increase the ATC at these points. This information is included in utility Transmission Ranking Cost Reports (TRCR).[7]

California Non-CAISO Interconnection Points

POUs do not make their ATC publicly available. To develop transmission availability for non-CAISO transmission, RETI will seek comparable data for POU interconnection points in California, but outside of the CAISO control area.

Non-California Interconnection Points

RETI anticipates that there will be a substantial quantity of renewable resources identified outside of California. To deliver energy to California, generators must interconnect to the local utility and transmit the power to the CAISO control area.

There is currently limited interstate transmission capacity available to import energy into California, though several proposed high-voltage transmission facilities that would increase energy transfer capacity to California are currently being studied by the Western Energy Coordinating Council (WECC). For Phase 1, RETI will assume that all non-California renewable generation will require new high voltage transmission to send energy to California. The cost of the transmission will be based on the cost of a new 500 kV transmission link from the generating facility to the California grid interconnection point, assigned on a pro-rata basis. Additionally, per recommendation of the CAISO, imports of power from outside of California will be limited. The limits are 2,500 MW from the Pacific Northwest (Oregon, Washington, British Columbia), 2,500 MW from the southwest (Arizona/Nevada).

[7] The latest version of the TRCRs at the time of this writing included:
"Pacific Gas and Electric Company 2008 Solicitation Protocol", February 29, 2008. http://www.pge.com/includes/docs/pdfs/b2b/wholesaleelectricsuppliersolicitation/2008protocolagreementRev022908.pdf; "SCE Conceptual Transmission Requirements and Costs for Integrating Renewable Resources", September 6, 2007., http://www.sce.com/nrc/rfp/2008_RPS_Appendix_D_SCE_TRCR.pdf,; "Transmission Ranking Cost Report of San Diego Gas & Electric Company (U 902E) for Renewable Portfolio Standard Procurement", September 10, 2007, http://www.sdge.com/regulatory/tariff/svc%20TRCR%20Filing.pdf .

Deleted: Cost

Table 3-8. Resource Valuation.	
Ranking Cost = Cost – Value	
Costs:	**Value:**
Generation Costs	Energy Value
+	+
Transmission Cost	Capacity Value
+	
Integration Costs	

The resource valuation methodology was presented to and discussed by the Phase 1A Working Group. For determination of capacity value, the Phase 1A Working Group suggested that determination of resource availability be based on average generation during summer months rather than average availability in all months. This change was incorporated into the resource valuation methodology.

3.7.1 Generation Cost

The cost of generation is calculated as a levelized cost of energy ("LCOE") at the point at which the project will interconnect to the existing transmission system. The LCOE for a project is the total life-cycle cost of generating electricity at the facility normalized by the total generation from the facility and is calculated in terms of dollars per megawatt hour ($/MWh). LCOE provides a consistent basis for comparing the economics of disparate projects across all technologies and ownership.

For each project or resource class, a pro forma financial analysis is conducted to determine the life-cycle cost. This pro forma model uses input assumptions for key project variables to determine expected revenues, costs, and year-by-year after-tax cash flow over the project life. The pro forma model used in RETI is consistent with that used by the CEC in its Cost of Generation model. It is also very similar to the model used by the CPUC to calculate the Market Price Referent (MPR), with the necessary modifications to make the calculations appropriate for renewable resources, including the modeling of tax incentives, accelerated depreciation, and other incentives.

The analysis includes appropriate assumptions for each project. Some assumptions are tailored to be technology specific, such as financing terms and appropriate tax incentives. Other assumptions such as capacity factor and capital cost may depend on geography and the available natural resource. Generally, these will be assessed on a project-specific basis for California resources, and on a higher-level,

Deleted: These

Deleted: in Phase 1B. Facility-specific resource class basis for out-of-state resources. Specific costs included in the generation costs are:

- Capital costs
- Generation interconnection costs ("gen-tie")
- Fixed operation and maintenance
- Variable operation and maintenance
- Heat rate (if applicable)
- Fuel costs (if applicable)
- Incentives
- Net plant output
- Capacity factor
- Economic life
- Cost for environmental mitigation (if necessary, and identified)

General economic, financing and incentive assumptions common for technology classes are discussed in Section 4, while technology-specific performance and cost assumptions are discussed in Section 5.

3.7.2 Transmission Cost

Similar to generation costs, transmission costs in the Phase 1 analysis will be calculated as the levelized cost of transmission ("LCOT"). This includes the cost of any transmission network infrastructure upgrades required to interconnect with the grid, and also all wheeling charges (transmission access charge for CAISO) to deliver the energy. The cost of connecting the generating project to the grid (or "gen-tie" cost) is part of the facility costs and will be included in the generation cost of the project. The LCOT for a project is the total cost of transmission upgrades normalized by the total generation from the facility and is calculated in terms of ($/MWh). Wheeling costs are be added to the network costs.

Transmission assumptions will vary by project, depending on the location, interconnection point, and transmission upgrades required to provide transmission access to the facility. For instance, a project located in Washington and selling into the California market will pay wheeling costs from its point of interconnection to the CAISO, and will also pay the CAISO transmission access fee.

3.7.3 Integration Cost

The integration cost of a project is the indirect operational cost to the transmission system to accommodate the generation from the project into the grid. The addition of substantial amounts of intermittent and as-available renewable resources will result in substantial generation swings on the transmission system, and the grid operator must accommodate these swings by ensuring there is sufficient regulation service, modifications to current daily ramps, additional reserve capacity and voltage support. Additional integration costs will include wear-and-tear on resources if they are required to repeatedly cycle to adjust for the intermittent resource output. The CAISO released an Integration of Renewable Resources analysis in November 2007 and determined that to add an additional 4,100 MW of wind resources in the Tehachapi area would require additional regulation service and adjustments to current ramping practices.[8]

While there is anecdotal evidence that large scale integration of renewable resources will result in additional system costs, these costs have not been quantified to date for California. It is expected that the costs will be relatively small compared to the generation and transmission components of the cost analysis. Unless a vetted assumption comes available soon, RETI will not use an integration cost in Phase 1, though Black & Veatch recommends that this issue be reconsidered in the RETI Phase 2 and subsequent analyses.

3.7.4 Capacity Value

The capacity value of a generating resource is based on its ability to provide dependable and reliable capacity during peak periods when the system requires reliable resources for stable operation. Resources that can provide firm capacity will have a higher capacity value than resources that cannot. In California capacity value is assessed by the resource adequacy value. Current resource adequacy practice considers the average resource capacity factor during the 12:00 p.m. – 6:00 p.m. period year-round. However, based on guidance from the Phase 1A Working Group, RETI will limit this to determination of capacity factor during the summer months (June-September). For the purposes of RETI, this average summer peak capacity factor is known as the "capacity credit."

The baseline value of capacity is the cost of the next most likely addition of low-cost capacity, defined as the fixed carrying costs of a simple cycle gas turbine generator. This includes the capital costs, fixed operations and maintenance costs, and other fixed charges associated with the gas turbine generator capacity, expressed as a dollar per kilowatt per year ($/kW-year). The capacity value does not include variable costs, such as fuel purchases.

[8] California Independent System Operator, "Integration of Renewable Resources", available at: http://www.caiso.com/1ca5/1ca5a7a026270.pdf, November 29, 2007.

This baseline capacity value is adjusted for each project based on its capacity credit. Resources that are more "firm" receive a higher capacity credit. As discussed previously, the capacity credit is the average capacity factor for a project during the period from 12:00 p.m. – 6:00 p.m. during summer months. For new projects, this is derived from the projected 24 hour by 12 month generation profile for the resource. When projects are near currently operating generation, the CAISO's net qualifying capacity (NQC) values can be used to help determine an appropriate capacity credit.[9] For example, for new wind resources in the Southern California Edison territory, the capacity credit would be 23 percent. For simplification, the comparative capacity credit for the baseline gas turbine generator is assumed to be 100 percent.

There are other methods to calculate the capacity credit, such as the effective load carrying capability (ELCC), that might be more accurate. However, basing the capacity credit on the current resource adequacy approach is relatively straightforward from an analytical perspective and also consistent with current regulatory practice.

The example Table 3-9 shows the capacity value calculation for three hypothetical projects based on a hypothetical baseline capacity value of $100/kW-year and hypothetical capacity factors. This example is included for illustrative purposes only. The capacity value in dollars per kilowatt-year is calculated by multiplying the capacity credit by the baseline capacity value. The formula for calculating capacity value ($/kW-yr) is:

Capacity Value ($/kW-yr) = (Capacity Credit) x (Baseline Capacity Value)

Table 3-9. Example Capacity Value Calculation.

	Wind	Solar	Biomass / Geothermal
Capacity Credit (CF in summer 12-6)	25%	90%	100%
Baseline Capacity Value ($/kW-yr)	$100	$100	$100
Capacity Value ($/kW-yr)	$25	$90	$100
Note: Hypothetical example, for conceptual illustration only.			

The baseline capacity value is the levelized fixed cost of a simple cycle gas turbine generator, owned by a merchant generator. This value is sourced from the CEC Cost of Generation report. The determination is outlined below in Table 3-10.

[9] CAISO, "NQC, Local Area Data and TAC Wind Factor Data for Compliance Year 2008 – Final"

Deleted: Kilowatt-years are then converted to megawatt-hours using the project's annual capacity factor.

Deleted: MWh

Deleted: *MWh) =* ¶

Deleted: */ 8760 hr / (Capacity Factor)*

Deleted: Annual Capacity Facto ... [2]

Deleted: s

3.7.6 Ranking Cost

The generation cost, transmission cost, integration cost, capacity value, and energy value are combined in a single cost metric that represents the overall economic merit of a given project or CREZ. This is known as the ranking cost. The ranking cost is calculated using the following formula:

Ranking Costs =
Generation Cost + Transmission Cost + Integration Costs
- Energy Value - Capacity Value

The ranking cost represents the costs of a renewable energy resource above (or below) its energy and capacity value. A lower ranking cost (including negative values), is indicative of a more cost-effective renewable energy project.

3.7.7 Consideration of Uncertainty

It is very important to consider the uncertainty in the estimates used to value resources. By their very nature, these estimates include a margin of error. It would not be prudent to eliminate potential CREZs from consideration if the difference in their ranking cost is 5 percent, but the margin of error is 20 percent. For this reason, a methodology will be developed in Phase 1B to assess the impacts of uncertainty on the ranking process. It is important that the ranking protocol recognizes uncertainty, but also protects clarity of information and process efficiency.

3.8 Future Cost and Performance Projections

Despite recent cost increases driven by commodity price, high demand and a decline in the value of the U.S. dollar, development costs for renewable energy technologies have generally improved significantly over the past 30 years. These trends may continue in the future as new concepts are introduced, tested in pilot and demonstration programs, and then accepted in the marketplace.

The technologies under consideration for this study include:

- Solid biomass
- Anaerobic digestion
- Landfill gas
- Solar thermal
- Solar photovoltaics
- Hydroelectric
- Wind (onshore and offshore)

3.10.3 CREZ Characterization and Ranking

Technical and economic characteristics of CREZs reflect the projects that comprise that CREZ. With the exception of transmission cost (discussed earlier in the Transmission Methodology section), the economic characteristics of a CREZ (or sub-CREZ) will simply be the sum or weighted average of the constituent project characteristics. These economic characteristics include:

- Capacity (MW)
- Generation (GWh/yr)
- Capacity factor
- Development time-frame
- Capital cost
- Operating and maintenance costs
- Fuel costs (if applicable)
- Resource valuation (generation, transmission, energy, capacity)
- Ranking cost

Each CREZ will then be assigned an economic ranking cost, analogous to the ranking cost assigned to each project as discussed in Section 3.7.6, and the CREZs will be ranked in comparison to each other and to any individual, stand-alone projects. The exact details of the comparison process including consideration of uncertainty will be developed in Phase 1B.

Deleted: .

Economics are not the only basis for which CREZs should be evaluated, they just happen to be the metric for which there are long-established and accepted electricity planning protocols. Other factors might include resource certainty, environmental impacts, and socioeconomic concerns.

In Phase 1B the Environmental Working Group will develop environmental criteria to include in the CREZ ranking process. This would allow environmental impacts to be assessed similar to the resource valuation process proposed for economic ranking. Black & Veatch will work with the EWG and the SSC to include such considerations in Phase 1B.

The final ranking procedure and methodology to combine different factors (economic, environmental, socioeconomic, etc.) has not been determined. This will need to be addressed in Phase 1B prior to prioritization of CREZs for further consideration in Phase 2.

4.0 General Study Assumptions

This section documents the RETI Phase 1 general assumptions. This includes a discussion of the economic assumptions that apply to all new renewable projects, the financial incentives available for projects, and the RPS requirements to be met. The numerous assumptions for renewable technologies are discussed in Section 5.

Deleted: , and future cost and performance projections

RETI Phase 1 assumptions were discussed by the Phase 1A Working Group in several meetings. The Phase 1A Working Group was generally supportive of the assumptions and recommended several modeling enhancements that will be incorporated into the study.

The assumptions included in this Phase 1A report are Black & Veatch's best assumptions at the time of publication. Refinement of both the accuracy and precision of these assumptions will continue through Phase 1B.

4.1 Economic Assumptions

Generation cost for each project is the levelized cost of energy over the life of a project. This cost is calculated by means of a pro forma financial model that characterizes the economic performance given project-specific characteristics and common assumptions about project ownership and financing for each technology type.

4.1.1 Ownership Structure

Both utilities and non-utilities can own renewable energy projects. Project ownership structure has an impact on project financing assumptions and available renewable energy incentives. For the purposes of modeling, RETI assumes that non-utility independent power producers (IPPs) own all projects, with some special exceptions.

With the notable exception of hydroelectric facilities, renewable energy projects have typically been owned by industrial and independent power producers (IPPs) with excess power sold to utilities through long-term power purchase agreements (PPAs). At the end of 2007, out of a total of about 32,000 MW of non-hydro renewable capacity installed in the US, only about 3,800 MW was owned by utilities (roughly 10 percent).[10] In California, the utility-owned fraction is even smaller. This historical dominance of IPP ownership stems from the rules of the Public Utilities Regulatory Policy Act of 1978 and the standard offer contracts of the 1980s. An additional consideration is that the

[10] Source: Black & Veatch query of Ventyx Energy Velocity database, January 21, 2008.

double) declining-balance depreciation, while other equipment may also receive less favorable depreciation treatment. Renewable energy property that will receive MACRS includes solar (5-year), wind (5-year), geothermal (5-year) and biomass (7-year). Typically, the majority of the project capital cost, but not all, can be depreciated on an accelerated schedule. However, for biomass, only the boiler portion of the plant receives MACRS (about 60 percent of the project cost).

The accelerated depreciation law also specifies that the depreciable basis is reduced by the value of any cash incentives received by the project, and by half of any federal investment tax credits (e.g., the ITC). This provision has the effect of lowering the depreciable basis to 95 percent for projects that receive the 10 percent ITC (and 85 percent for projects that take the 30 percent ITC).

4.2.2 U.S. Federal Non Tax-Related

Government-owned utilities and other tax-exempt entities are not able to directly take advantage of tax incentives. Tax-exempt entities, however, do enjoy a number of other benefits when financing and operating capital investments. The most obvious benefit is freedom from federal and state income tax liability. Depending on project location and local laws, payment of property taxes may also be reduced or eliminated. These entities are also able to issue tax-exempt debt, which carries lower interest rates than comparable corporate debt. As discussed previously, the default ownership assumption for RETI is IPP ownership, so these considerations will only be taken into account for specific publicly owned projects that are identified.

Deleted: -

The federal government has established two other primary incentive programs for non-taxable entities. These are the Renewable Energy Production Incentive (REPI) and Clean Renewable Energy Bonds (CREBs). Neither program is intended for privately-owned projects, and both rely on limited congressional appropriations. For these reasons, RETI assumes that no project will benefit from these programs.

4.2.3 U.S. State Financial Incentives

All U.S. states within the RETI study area have incentives for renewable energy projects. Black & Veatch reviewed the incentives and concluded that none would have a substantive effect on the analysis. Therefore, for the sake of simplicity, the Phase 1 assessment does not include state incentives.

4.2.4 British Columbia Incentives

British Columbia has an accelerated depreciation program and tax breaks for renewable energy. In addition, the province recently announced that a feed-in tariff is currently in development.

The central government has also recently established the EcoENERGY for Renewable Power program. This program will provide an incentive of 1 cent (CND) per kWh for up to 10 years for eligible low-impact, renewable electricity projects constructed from April 1, 2007 to March 31, 2011.

While the incentives available to renewable energy projects in British Columbia are not the same as those available to U.S. projects, the net effects are similar. For simplicity, the Phase 1 assessment models projects in British Columbia with the same incentive assumptions as projects located in the U.S.

4.2.5 Baja California, Mexico

Mexico has no noteworthy financial incentives for renewable energy development. The Phase 1 assessment models projects in Baja California without the benefit of the U.S. Federal tax credits.

4.2.6 Future Term and Nature of Incentives

The future of financial incentives is a source of uncertainly in the RETI analysis. Currently, the eligibility period for the PTC and 30 percent ITC expire at the end of 2008. Both of these incentives have a substantial impact on the cost of generation from renewables. Black & Veatch discussed this issue extensively with the Phase 1A Working Group. There is little basis on which to forecast future incentives. However, it was widely accepted that incentives will, in general and in some form, be available to renewable energy projects over the term of this study. The decision of the Phase 1A Working Group was to assume that existing financial incentives extend in their current form through the RETI study period. The model will allow the ability to "toggle" specific incentives to see the sensitivity of the results to this assumption.

Deleted: working group

4.3 Renewable Energy Demand

The RETI Phase 1B analysis forecasts the demand for renewable energy in California in order to determine the quantity of new generation that must be built. Demand is a function of California load growth, assumptions about the state's RPS, and treatment of existing resources.

California was among the first states to enact a renewable portfolio standard and currently has one of the most aggressive portfolio requirements in the country. California has adopted an RPS requiring that 20 percent of electric energy be generated from renewable resources by 2010 (2013 with flexible compliance).[12] The Governor and the state's Energy Action Plan have endorsed a further goal of 33 percent renewables by 2020, in part, as a possible strategy for meeting the greenhouse gas emission reduction requirements of AB 32.[13] The RETI analysis assumes the 33 percent standard.

The Phase 1A Working Group reviewed the Phase 1 renewable demand assumptions and agreed that these were appropriate. It was noted that publicly owned utilities are not subject to the same RPS requirements as investor owned utilities. However, most have developed similar renewable goals, and it was agreed that the state's requirements for investor owned utilities were an appropriate proxy for all load-serving entities.

The Phase 1A Working Group also discussed whether the California Solar Initiative's (CSI) projected 3,000 MW of solar photovoltaics should be considered as a resource that will count towards the state's 33 percent renewable goal. The Phase 1A Working Group decided that it was likely that half of the CSI energy would somehow be used by load serving entities for RPS compliance. This will add approximately 0.7 percent renewables to the California system in 2016. RETI Phase 1 will model this energy as a renewable project.

4.3.1 California Load Growth

To project future renewable requirements RETI is using the CEC statewide load forecast prepared as part of the 2007 Integrated Energy Policy Report (2007 IEPR). The IEPR load forecast extends through 2018. To forecast loads for years 2019 and 2020 RETI inflated the 2018 statewide total electric load by 1.3 percent per year. The 1.3 percent value is the average annual growth rate in the CEC forecast.[14]

4.3.2 RPS Assumptions

RETI considers three RPS target points for generation in the analysis. The near term target is the 20 percent requirement, which RETI assumes, with flexible compliance,

---

[12] SB 1078 established an RPS of 20% by 2017. The Energy Action Plan, adopted by the Commission and the California Energy Commission (CEC) in May 2003, accelerated the completion date to 2010. SB 107, passed in 2006, codified that policy.

[13] Assembly Bill 32, Ch. 488, Stats. 2006. Executive Order S-3-05, signed by the Governor on June 1, 2005, establishes greenhouse gas emission reduction goals for California and identifies acceleration of the renewable energy goals to 33% of energy sales by 2020 as one strategy to meet those goals. See "Strategies Underway in California That Reduce Greenhouse Gas Emissions" at http://www.climatechange.ca.gov/climate_action_team/factsheets/2005-06_GHG_STRATEGIES_FS.PDF

[14] California Energy Commission, "California Energy Demand 2008 - 2018: Staff Revised Forecast, FINAL Staff Forecast, 2nd Edition", Publication # CEC-200-2007-015-SF2, November 27, 2007.

5.0 Technology Assumptions

This section discusses the renewable energy technologies considered by the RETI analysis. Each discussion includes a description of the technology and an outline of the cost and performance assumptions used to model it in the analysis. The objective of this section is to characterize the various renewable energy technologies suitable for application in California and neighboring areas. The information contained in this section will be used as a starting point for project characterization in Phase 1B.

Deleted:

The assumptions included in this Phase 1A report are Black & Veatch's best assumptions at the time of publication. Refinement of both the accuracy and precision of these assumptions will continue through Phase 1B.

Technologies to harness renewable energy are diverse and include wind, solar, biomass, biogas, geothermal, hydroelectric, and ocean energy. Steady advances in equipment and operating experience spurred by government incentives have lead to many mature renewable technologies. The technical feasibility and cost of energy from nearly every form of renewable energy have improved since the early 1980s. However, in most countries the renewable fraction of total electricity generation remains small. This is true despite a huge resource base that has potential to provide many multiples of current electricity demand. Nevertheless, the field is rapidly expanding from the niche markets of the past to making meaningful contributions to the world's electricity supply.

The technologies evaluated in Phase 1A of RETI are:

- Solid biomass
  - Direct fired
  - Cofiring
- Biogas
  - Anaerobic digestion
  - Landfill gas
- Solar
  - Solar thermal electric
  - Solar photovoltaic
- Hydroelectric
- Wind
  - On-shore
  - Off-shore
- Geothermal
- Ocean

Biomass plants usually have a capacity of less than 50 MW because of the dispersed nature of the feedstock and the large quantities of fuel required. As a result of the smaller scale of the plants and higher moisture content of the fuels, biomass plants are commonly less efficient than modern fossil fuel plants. In addition to being less efficient, biomass is usually more expensive than coal on a $/MBtu basis because of added transportation costs. These factors usually limit the use of direct-fired biomass technology to inexpensive or waste biomass sources.

Deleted: lower heating values

Deleted: generally

Deleted: conventional fossil fuels

Resource Availability

To be economically feasible, dedicated biomass plants are located either at the source of a fuel supply (such as at a sawmill) or within 50 miles of numerous suppliers (up to 200 miles for a very high quantity, low cost supplier). Wood and wood waste are the primary biomass resources and are typically concentrated in areas of high forest-product industry activity. In rural areas, agricultural production can often yield significant fuel resources that can be collected and burned in biomass plants. These agricultural resources include bagasse, corn stover, rice hulls, wheat straw, orchard prunings, orchard removals, and other residues. Energy crops, such as switchgrass and short rotation woody crops, have also been identified as potential biomass sources. In urban areas, biomass is typically composed of wood wastes such as construction debris, pallets, yard and tree trimmings, and railroad ties. Locally grown and collected biomass fuels are relatively labor intensive and can provide substantial employment benefits to rural economies. In general, the availability of sufficient quantities of biomass is less of a feasibility concern than the high costs associated with transportation and delivery of the fuel.

Based on recent biomass resource assessments that Black & Veatch is familiar with, the expected cost of clean wood residues can vary as much as 100 percent depending on the type of residue, quantity, and hauling distance.

Cost and Performance Characteristics

Table 5-1 presents the typical characteristics of a 35 MW stoker boiler biomass plant with Rankine cycle using wood as fuel. Capital costs for stand-alone biomass plants can range significantly, depending on land costs, construction labor costs, and the availability of existing transmission. Areas with high costs for land and construction labor and without existing transmission will approach the upper end of the capital cost range presented in Table 5-1. For stand-alone biomass plants, two fuel costs scenarios were evaluated: (1) a relatively lower cost ($1.00/MBtu) scenario which would be based primarily on urban wood waste sources in the major metropolitan areas, and (2) a moderate cost ($2.50/MBtu) scenario which would be more representative of a project using forest thinnings and forestry residues. Actual fuel cost could vary significantly from the values characterized here based on local supply and demand, and transportation distance. For example, Black & Veatch has previously estimated costs for biomass resources at greater than $3/MBtu in some parts of the western United States. In these cases, transport distances were up to 200 miles. Another possible biomass fuel is dedicated energy crops, which are grown specifically to provide feedstock for biomass plants. However, experience with energy crops is very limited, and costs for these fuels would likely approach $4.00/MBtu or greater. For these reasons, electricity costs for energy crops are not provided.

Table 5-1. Direct-Fired Biomass Combustion Technology Characteristics.

Performance	
Typical Duty Cycle	Baseload
Net Plant Capacity (MW)	35
Net Plant Heat Rate (HHV, Btu/kWh)	14,000 – 17,500
Capacity Factor (percent)	80
Economics	
Total Project Cost ($/kW)	3,000 to 4,500
Fixed O&M ($/kW-yr)	83
Variable O&M ($/MWh)	11
Fuel Cost ($/MBtu)	0 to 3
Levelized Cost of Energy ($/MWh)	67 to 140
Applicable Incentives	Open loop: $10/MWh PTC, 7-yr MACRS Closed loop: $20/MWh PTC, 7-yr MACRS
Technology Status	
Commercial Status	Commercial
Installed US Capacity (MW)	7,700*

* Source: Black & Veatch query of Ventyx Energy Velocity database, March 11, 2008. This number represents solid biomass fired facilities where biomass is the primary fuel. Many biomass boilers also have the ability to burn supplemental fuels, such as coal and pet coke. While biomass is listed as the primary fuel for all 7,700 MW, about 1,300 MW of the total capacity also burns coal, pet coke, or tire chips as a secondary fuel.

Deleted: 5,000

Deleted: 150

Deleted: 000

Formatted Table

Environmental Impacts

Biomass power projects must maintain a careful balance to ensure long-term sustainability with minimal environmental impact. Most biomass projects target utilization of biomass waste material for energy production, saving valuable landfill space. Biomass projects that burn forestry or agricultural products must ensure that fuel harvesting and collection practices are both sustainable and do not adversely affect the environment. On the positive side, biomass projects that collect forest thinnings to reduce the risk of forest fires may be seen as a way to restore a positive balance to forest ecosystems while avoiding catastrophic and polluting uncontrolled forest fires. On the other hand, forest thinning projects that propose to log old-growth lumber, clearly need to be examined with great caution, and are likely not sustainable.

Deleted: are increasingly

Unlike fossil fuels, biomass is viewed as a carbon-neutral power generation fuel. While carbon dioxide (CO_2) is emitted during biomass combustion, a nearly equal amount of carbon dioxide is absorbed from the atmosphere during the biomass growth phase. Further, biomass fuels contain little sulfur compared to coal and therefore produce less sulfur dioxide (SO_2). Finally, unlike coal, biomass fuels typically contain only trace amounts of toxic metals, such as cadmium, and lead. However, biomass combustion still must include technologies to control emissions of nitrogen oxides (NO_x), particulate matter (PM), and carbon monoxide (CO) to maintain Best Available Control Technology (BACT) standards.

In addition to the above considerations, biomass can also be viewed in some situations as actually reducing emissions compared to the status quo. For example, rice straw burned in an efficient biomass power plant with emissions control equipment will produce far fewer emissions than open-field burning.

5.1.2 Biomass Cofiring

One of the most economical methods to burn biomass is to cofire it with coal in existing plants. Cofired projects are usually implemented by retrofitting a biomass fuel feed system to an existing coal plant, although greenfield facilities can also be designed to accept a variety of fuels.

As discussed in the previous section, a major challenge to biomass power is that the dispersed nature of the feedstock and high transportation costs generally preclude plants larger than 50 MW. By comparison, coal power plants rely on the same fundamental power conversion technology but can have much higher unit capacities, exceeding 1,000 MW. As a result of this larger capacity, modern coal plants are able to obtain higher efficiency at lower cost. Through cofiring, biomass benefits from this higher efficiency through a more competitive cost than a stand-alone, direct-fired biomass plant.

primary capital cost for the project would be related to the biomass material handling system. As with direct fired biomass, biomass fuel cost is assumed to range from \$1.00/MBtu for urban wood residues to \$2.50/MBtu for forestry residues. To calculate the incremental fuel cost, coal has been assumed at a base cost of \$1.50/MBtu. The incremental biomass cost is then -\$0.50/MBtu to \$1.00/MBtu. Thus on the low-end, the biomass fuel cost is actually assumed to be \$0.50/MBtu less expensive than coal.

Analysis of the range of incremental levelized costs presented in Table 5-2 indicates that the costs to cofire biomass with coal would be relatively small. The analysis shows that the cost ranges from negligible (due to fuel possibly being cheaper than the coal it displaces) up to \$22 per MWh.

Capital costs range from \$300 to \$500. The difference between a high and a low value in this range depends on the magnitude of material handling and fuel processing equipment is required.

Table 5-2. Cofired Biomass Technology Characteristics.

Performance	
Typical Duty Cycle	Typically baseload, depends on host
Net Plant Capacity (MW)	35
Net Plant Heat Rate (Btu/kWh)	Increase 0.5 to 1.5 percent
Capacity Factor (percent)	Unchanged
Economics (Incremental Costs in 2008\$)	
Total Project Cost (\$/$kW_{biomass}$)	300 to 500
Fixed O&M (\$/$kW_{biomass}$-yr)	5 to 15
Variable O&M (\$/$MWh_{biomass}$)	Included with fixed
Fuel Cost (\$ incremental to coal price)	-0.5 to 1
Levelized Cost (\$/$MWh_{biomass}$)	-1 to 22
Applicable Incentives	None
Technology Status	
Commercial Status	Established, not fully commercial

Deleted: 2007

Environmental Impacts

As with direct-fired biomass plants, the biomass fuel supply must be collected in a sustainable manner. Assuming this is the case, cofiring biomass in an existing coal plant generally has overall positive environmental effects compared to 100 percent coal combustion. The clean biomass fuel typically reduces emissions of SO_2, CO_2, NO_x, and heavy metals such as mercury. Further, compared to other renewable resources, biomass

Deleted: a

5.3.4 Environmental Impacts

Combustion of LFG releases pollutants similar to those released by many other fuels, but the combustion of LFG is generally perceived as environmentally beneficial. Since LFG is principally composed of methane, if it is not combusted, LFG is released into the atmosphere as a greenhouse gas. As a greenhouse gas, methane is 23 times more harmful than CO_2. Collecting the gas and converting the methane to CO_2 through combustion greatly reduces the potency of LFG as a source of greenhouse gas emissions.

5.4 Solar Thermal

The performance, commercial readiness, cost, reliability, and technical risk of solar thermal electric technologies are characterized in this section. The technologies discussed include:

- Parabolic trough
- Parabolic dish
- Power tower
- Compact Linear Fresnel Reflector (CLFR)
- Solar Chimney

Deleted: •
Formatted: List Bullet
Deleted: •
Deleted: •
Deleted: •
Deleted: ¶

Thermal plants consist of two major subsystems: a collector system that collects solar energy and converts it to heat, and a power block that converts heat energy to electricity. Concentrating solar thermal power plants (CSP) produce electric power by collecting the sun's energy to generate heat using various mirror or lens configurations. For solar thermal electric systems, the heat is transferred to a turbine or engine for power generation. Other solar thermal systems, like the solar chimney, collect solar heat without the aid of concentrators.

Deleted: converting
Deleted: into high temperature
Deleted: (trough, dish-Stirling, and power tower)
Deleted: Thermal plants consist of two major subsystems: a collector system that collects solar energy and converts it to heat, and a power block that converts heat energy to electricity.

All CSP systems make use of the direct normal insolation (DNI) component of solar radiation, that is, the radiation that comes directly from the sun. Global radiation, which is reflected radiation, is present on sunny and cloudy days but is unusable by CSP systems. Since all CSP systems use DNI and concentration of DNI allows a solar system to achieve a high working fluid temperature, there is a need for the collector systems to track the sun. Parabolic trough and CLFR systems use single-axis trackers to focus radiation onto a linear receiver, while dish-Stirling and power tower CSP systems use two-axis trackers.

Trough, power tower, CLFR, and chimney systems collect heat to drive central turbine-generators making them best suited for relatively large plants—50 MW or larger. Trough, tower and CLFR plants, with their large central turbine generators and balance of

Deleted: CLFR

plant equipment, have a cost advantage of economy of scale—that is, cost per kW goes down with increased size. Dish systems are modular in nature, with single units producing power in the range of 5 kW to 35 kW making them ideal for distributed or remote generation applications. Dish systems can also be sited as large plants by aggregating many units. Dish systems have the potential advantage of mass production of individual units, similar to the mass production of automobiles.

Deleted: 10

Trough and tower systems have the potential advantage over dish systems in that an amount of dispatchability can be designed into the system with thermal storage or the use of hybrid fossil fuel. Storage for CLFR systems, while being explored in concept, has not been developed. Dispatchability allows the solar plant to generate electricity during short duration cloudy periods or to generate electricity into the evening after sunset. This gives the plant potential to receive capacity credit, and provides the ability to more closely match the utility peak load profile. At this time, dish-Stirling systems have not been configured to provide hybrid fossil capability.

Solar chimney systems behave differently from the other solar technologies in that they can continue to produce electricity beyond sunny periods without the use of thermal storage systems or fossil fuels. Only a residual heat difference is needed.

5.4.1 Parabolic Trough Systems

Parabolic trough solar thermal systems have been the dominant solar thermal technology installed to date. Parabolic trough systems concentrate DNI using single axis tracking, parabolic curved, trough-shaped reflectors onto a receiver pipe or heat collection element (HCE) located at the focal line of the parabolic surface. A high temperature heat transfer fluid (HTF) picks up the thermal energy in the HCE. Heat in the HCE is then used to make steam in the steam generator. The steam drives a conventional steam-Rankine power cycle to generate electricity. Figure 5-4 shows trough collectors. A collector field contains many parallel rows of troughs connected in series. Rows are typically placed on a north-south axis, allowing the single-axis troughs to track the sun from east to west during the day.

and Solucar (Abengoa). Suppliers of components for trough systems include reflector supplier Flabeg and receiver suppliers Schott Glass and Solel Solar Systems. Other major glass companies have expressed interest in entering the trough mirror market. SkyFuel is another technology supplier developing a glass-free trough based on mirror films, a product developed at NREL as a substitute for glass mirrors.

The currently planned technology for thermal storage is the molten salt two-tank system. This provides a feasible storage capacity of up to 12 hours and is considered to have a low-to-moderate associated technology risk.

Deleted: ,

Deleted: ,

5.4.2 Parabolic Dish-Engine Systems

A solar parabolic dish-engine system comprises a solar concentrator (or "parabolic dish") and the power conversion unit (PCU). The concentrator consists of mirror facets which combine to form a parabolic dish. The dish redirects DNI to a receiver mounted on a boom at the dish's focal point. The system uses a two-axis tracker such that it points at the sun continuously.

A parabolic dish-engine system using a Stirling engine is shown in Figure 5-5. The PCU includes the thermal receiver and the engine-generator. In the solar receiver, radiant solar energy is converted to heat in a closed hydrogen loop, driving the Stirling engine-generator. Because the PCUs are air cooled, water cooling is not required. This is important because water cooling is necessary for the large, central power blocks associated with trough and power tower technologies. Thermal storage is not currently considered to be a viable option for dish-Stirling systems.

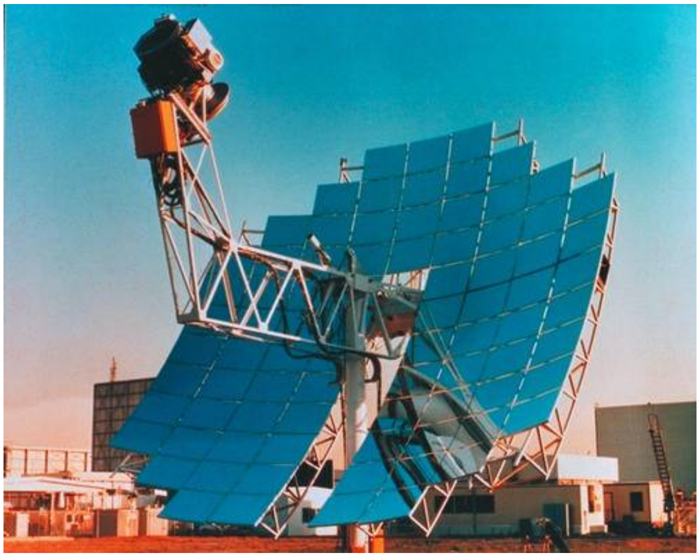


Figure 5-5. Dish-Stirling System (NREL).

Deleted: .

Relatively level land is preferable for construction and maintenance ease; however, siting requirements on slope are likely less stringent than those for trough and tower systems.

Individual dish-Stirling units range in size from 5 to 25 kW. Because they can operate independent of power grids, they can be used for remote applications as well as grid connected applications. With their high efficiency and modular construction, the cost of dish-engine systems is expected to be competitive in distributed markets. Stirling Engine Systems (SES), the principal dish-Stirling developer in the United States, projects that the cost of dishes will decrease dramatically with hundreds of MWs of central station, grid connected deployment.

Deleted: 10

At the present time, there are no operating commercial dish-Stirling power plants. A six dish test deployment at Sandia National Laboratories (SNL) in Albuquerque, New Mexico, was completed in 2005. This development is under a joint agreement between SES and SNL. In 2005, Southern California Edison publicly announced the completion of negotiations on a 20 year power purchase agreement with SES for between 500 to 850 MW of capacity (producing 1,182 to 2,010 GWh/year) of dish Stirling units. Also in 2005, SES announced a contract with San Diego Gas & Electric to provide between 300 and 900 MW of solar power using the dish technology. If successful, this large deployment of dish Stirling systems is expected to drastically reduce capital and O&M costs and result in increased system reliability.

An advantage of power tower plants is that molten salt can be heated to 1,050°F, with steam generation at 1,000°F, which is utility-standard main steam temperature. This results in slightly higher cycle efficiency than is achievable with the lower temperature (about 700°F) steam produced in a trough system. Furthermore, power towers have the advantage that the molten salt is used both as the HTF and as the storage medium, unlike the trough system which uses high temperature oil as the HTF, and requires oil-to-salt and salt-back-to-oil heat exchange for thermal storage. The result is that storage is less costly and more efficient for power towers than for troughs.

A 10 MW power tower plant, Solar One, located near Barstow, California, operated from 1982 to 1988 and produced over 38 million kilowatt-hours (kWh) of electricity. Solar One generated steam directly in the receiver. To implement improved heat transfer and thermal storage, the plant was retrofitted (and renamed Solar Two). Solar Two operated from 1998 to 1999. Although Solar Two successfully demonstrated efficient collection of solar energy and dispatch of electricity, including the ability to routinely produce electricity during cloudy weather and at night, the plant encountered various technical issues. Solutions to these issues have been identified; however, successful demonstration of certain improvements is required prior to commercial financing of a large-scale plant.

In addition to Solar One and Solar Two, experimental and prototype systems have operated in Spain, France, and Israel. Solucar Energia, S.A., an Abengoa company, recently announced the completion of an 11 MW solar power tower near Seville, Spain. Called PS 10, the power plant is the first tower-based solar power system to generate electricity commercially. PS 10 uses a water-steam receiver. Solucar has plans for a 20 MW plant, which also uses a water-steam receiver. In addition, ESKOM, the largest utility in South Africa, is considering a 100 MW molten-salt plant. The primary developer of molten salt technology for power towers is Solar Reserve, a joint venture between United Technologies Corporation and US Renewables.

Two US companies, eSolar and Brightsource, are pursuing “distributed power tower” concepts. These use smaller heliostats and smaller towers, and use several towers to provide steam for a single turbine. Both of these companies are still in the technology development stage, with no working demonstration plant.

5.4.4 Compact Linear Fresnel Reflector (CLFR)

Deleted: *Lens*

The compact linear Fresnel reflector (CLFR) is a solar thermal technology in which rows of mirrors reflect solar radiation on a linear receiver located on towers above the mirror field. Ausra is developing a CLFR technology, and recently opened a Las Vegas manufacturing facility. Liddell 1, Ausra’s first generation CLFR system, is shown

- The saturated steam generated by the CLFR is relatively low temperature and being saturated, rather than superheated, results in less efficient power generation.
- The overall CLFR solar to steam efficiency is substantially lower than trough.

5.4.5 Solar Chimney

Unlike other solar thermal technologies, solar chimneys do not generate power using a thermal heat cycle. Instead, they generate and collect hot air in a large (several square miles) greenhouse. A tall chimney is located in the center of the greenhouse. As the air in the greenhouse is heated by the sun, it rises and enters the chimney. The natural draft produces a wind current that rotates a collection of dozens of ground mounted air turbines.

A prototype solar chimney was constructed in Spain in the early 1980's and operated for seven years. The tower height was 195 meters with a diameter of 10 meters and a greenhouse collection area of 46,000 m2 or 11 acres. It generated 50kW. The first large-scale solar chimney project was proposed in Australia. This 200MW facility would have a chimney 1 km tall and a collector 5 km in diameter.

There are three companies involved with solar chimney technology: Australian EnviroMission Ltd., German Schlaich Bergermann and Partner and US based SolarMission, Inc. All three companies have had various linkages (contracts, merger, etc) over several years.

5.4.6 Environmental Impacts

While solar thermal systems do not have air emissions of criteria pollutants (such as carbon dioxide, sulfur dioxide, or particulates), there can be other significant impacts. Concentrating solar thermal projects are large installations that require significant amounts of land, anywhere from 5 to 10 acres per MW. Plants can be wet or dry cooled. Wet cooled plants will use significant amounts of water, roughly 750 to 850 gallons per MWh. Dry cooled plants will use much less water, roughly 20 to 45 gallons per MWh, mostly for mirror (or heliostat) washing. Land would be cleared and fenced for installations, which could restrict wildlife movement. There would be significant disturbance during the construction phase of the project.

Deleted: Solar thermal projects are large installations that require significant amounts of land, anywhere from 7 to 10 acres per MW. Solar

Deleted: ,

Deleted: . Wet cooled plants will use significant amounts of water, but RETI has assumed that plants built in California will

Deleted: Some

Deleted: is required

5.4.7 Cost and Performance Characteristics

While there are several solar thermal technologies being actively promoted, the only technology commercially available today is parabolic trough. In addition, much of the commercial development interest appears to be for trough technology. Trough

Deleted: commercial

systems make up 84 percent of the BLM's California Desert District solar thermal applications, far more than dish or tower. Parabolic trough systems will therefore be used as a proxy for all solar thermal technologies, considering that the costs and performance for trough are better understood than for other technologies. Other technologies may have slightly different characteristics than trough, such as land use, efficiency, or ease of integrated storage; however these differences are not large. The levelized cost of energy as well as energy generation profile from trough should be roughly similar to that of other technologies. For the purposes of the RETI, using a single conversion technology is appropriate.

Black & Veatch does not believe that parabolic trough systems are the only commercially viable solar thermal systems, or that trough systems are the only technology that will be built. For the purposes of RETI, however, using a single technology as a proxy for all solar thermal technologies is appropriate.

Representative characteristics for a parabolic trough system without energy storage are shown in Table 5-5. Capital costs are expected to vary from $3,800 to $4,800/kW. One difference between a high cost and a low cost project depends on the level of site preparation needed, such as terracing and the construction of infrastructure. The need for dry cooling also raises project costs. In RETI Phase 1B, Black & Veatch will assume plants are either wet or dry cooled based on environmental criteria and availability of water at specific sites. Black & Veatch will look to the California Energy Commission and the RETI Environmental Working Group to provide guidance on water availability for solar thermal plants.

Deleted: and using dry cooling

Deleted: Dry cooling is assumed due

Deleted: lack of water and permitting requirements. Capital costs

Deleted: 600

Deleted: 200 per

Deleted: of capacity. The

Formatted Table

Table 5-5. Parabolic Trough Costs and Performance.

Performance	
Typical Duty Cycle	Peaking-Intermediate
Net Plant Capacity (MW)	200 MW
Integrated Storage	None
Capacity Factor (percent)*	26 -29
Economics ($2008)	
Total Project Cost ($/kW)**	3800 to 4800
Variable O&M ($/MWh)	N/A
Fixed O&M ($/kW)	66
Levelized Cost of Energy ($/MWh)	143 to 192
Applicable Incentives	30% Federal ITC; 5 year MACRS

Notes:
* Depends on location.
** Costs vary based on site characteristics

Deleted: 3600
Deleted: 4200
Deleted: 137
Deleted: 176
Deleted: ¶

5.5 Solar Photovoltaic

Due to its high cost, intermittency, and low capacity factor, solar photovoltaics (PV) have had little penetration into the bulk electricity market. While solar, in general, represents a very small portion of the overall electricity generated in the US, solar PV represents an even smaller fraction. However, there is recent strong growth being observed in the PV industry. In the US in 2007, 250 MW of grid connected PV was installed, which is nearly four times the installations in 2005. This section provides a background into the solar PV industry and the cost and performance of solar PV.

Deleted: 2006, 100
Deleted: triple
Deleted: 2003

5.5.1 Operating Principles

Solar PV converts sunlight (also known as insolation) directly into electricity. The power produced depends on the material involved and the intensity of the solar radiation incident on the cell. Single or polycrystalline silicon cells are most widely used today. Single crystal cells are manufactured by growing single crystal ingots, which are sliced into thin cell-size material. The cost of the crystalline material is significant. The production of polycrystalline cells can cut material costs, but with some reduction in cell efficiency. Thin film solar cells are made from layers of semiconductor materials only a few micrometers thick. These materials make applications more flexible, as thin film PV can be integrated into roofing tiles or windows. Thin film cells significantly reduce cost per unit area, but also result in lower efficiency cells. Gallium arsenide cells are among the most efficient solar cells and have other technical advantages, but they are also more costly and typically are used only where high efficiency is required even at a high cost, such as space applications or in concentrating PV applications. Additional advanced technologies are under development including dye sensitized solar cells (DSSC) and organic light emitting diodes (OLED). Developers of these technologies hope to achieve dramatic reductions in cell cost, but likely will have efficiencies on the lower end of the range for PV cells.

5.5.2 Markets

Currently, the commercial PV market is dominated by silicon-based cells, with about 85 percent market share for crystalline silicon. Recent shortages and cost increases of silicon have driven the market for new materials, such as cadmium telluride and amorophous silicon.

Deleted: Cadmium Telluride

Solar photovoltaics have achieved enviable growth over the last few years. Worldwide grid-connected residential and commercial installations grew from 170 MW per year in 2000 to an estimated 2,500 MW per year in 2007. The majority of these installations were in Japan and Germany, where strong subsidy programs have made the economics of PV very attractive. The US grid connected market was estimated to be 250 MW in 2007, with most of these installations in California.

A new development in the solar market has been the growth of larger, utility-scale systems. In the past, photovoltaics had been seen as a distributed technology suitable for rooftops and industrial applications. The largest photovoltaic system in the US was Tuscon Electric's 4 MW installation in Springerville, AZ. In 2007, two large photovoltaic systems were commissioned in the western US, an 6 MW system in southwestern Colorado and a 12 MW system at Nellis Air Force Base outside of Las Vegas. There are four large photovoltaic systems that have PPA's with California utilities, shown in Table 5-6. In addition, there is significant development interest in utility scale solar photovoltaics. There are over 7,000 MW of large photovoltaic projects in the California ISO queue, and 11,541 MW of applications for BLM rights-of-way in the California Desert District.

Deleted: 8

Deleted: 15

Table 5-6. Photovoltaic Projects with California PPAs.

Developer	MW	Location	Utility	Technology
First Solar Electric	7-21	Blythe	SCE	CdTe
Cleantech America	5	Mendota	PG&E	Crystalline
Green Volts	2	Byron	PG&E	CPV
Alternative Energy Development	1	Kern County	SCE	Unk.
Source: CEC contract database				

5.5.3 Concentrating Solar Photovoltaic Systems

Concentrating photovoltaic (CPV) plants provide power by focusing solar radiation onto a photovoltaic (PV) module, which converts the radiation directly to electricity. Either mirrors or lenses can be used to concentrate the solar energy for a CPV system. Most of the CPV systems use two axis tracking to achieve point focus images on PV cells. Single axis, line focus CPV systems have been built, but do not appear to have the long term commercial potential that the two axis tracking CPV systems have.

Concentrating photovoltaic (CPV) systems have potential for cost reduction compared with conventional, non-concentrating (also referred to as flat plate) PV systems in two key ways. First, a major portion of the conventional PV system cost is for the semiconductor material which makes up the PV modules. By concentrating sunlight onto a small cell, the amount of semiconductor material can be reduced, albeit at additional cost for mirrors or lenses and for tracking equipment. Recent rises in solar module prices due to semiconductor-grade silicon have made CPV more attractive. Second, use of smaller cells allows for more advanced and efficient cell technology, making the overall system efficiency higher than for a conventional flat plate system.

CPV systems have been under development since the 1970's. This development has included single axis tracking, line focus CPV, and two axis tracking, point focus CPV. Recent development has primarily been on the two-axis tracking systems. Developers of CPV technology include Amonix (Figure 5-8), Energy Innovations, Sharp, EMCORE, Isophoton and SolFocus. Green Volts, a CPV startup, has a contract with PG&E and is planning a 2 MW system.

Amonix systems have been deployed at Nevada Power (75 kW at Clark generating station) and Arizona Public Service (APS) facilities for a total capacity of over 600 kW. Planned deployments in the near future include 10 to 20 MW in Spain.

It is unclear if these CPV technologies will achieve their desired cost targets. It does appear, however, that CPV may be more appropriate for utility-scale PV due to reduced silicon use.

Deleted: lower land requirements and

Figure 5-8. Amonix: Flat Acrylic Lens Concentrator with Silicon Cells (NREL).

5.5.4 Resource Availability

Most PV systems installed today are flat plate systems that use global insolation. Global insolation is the direct normal component along with diffuse radiation. CPV systems require DNI, as discussed under the Solar Thermal section. Because photovoltaics use global insolation, they can be more flexibly sited that solar thermal or CPV systems.

Photovoltaics also have temperature characteristics that must be taken into account when modeling production from these systems. Crystalline silicon systems produce less energy in high temperatures conditions. Thin film systems are less susceptible to this temperature effect.

Deleted: areas

5.5.5 Environmental Impacts

Photovoltaic power systems are silent, unobtrusive, and require minimal water for washing. During normal operation PV power systems do not emit substances that may threaten human health or the environment. Large scale photovoltaic installations, however, would have significant land use impacts. A megawatt of photovoltaics requires roughly 7 acres. Land would be cleared for photovoltaic installations, and installations would likely be fenced, which could restrict wildlife movement. There would be significant disturbance during the construction phase of the project. Some water will be used during operations, mainly for washing modules. Water use would range from 5 to 10 gallons per MWh.

Deleted: 10

5.5.6 Cost and Performance Characteristics

For the purposes of RETI, Black & Veatch chose tracked crystalline photovoltaics as the representative photovoltaic technology. The two most recent utility scale photovoltaic plants in the US, Alamosa and Nellis, both use this technology. While thin film and concentrating systems show great promise, crystalline is the most mature at this point. Considering both initial capital cost and annual electricity production, Black & Veatch feels that the all-in cost for various photovoltaic technologies is similar (see Figure 5-9 for a graphical representation). In consideration of their future potential, Black & Veatch will run an alternate scenario using lower costs for thin film systems, with costs ranging from $2,700/kWe to $3,700/kWe. Table 5-7 shows the costs and performance for solar photovoltaic systems.

Deleted: From a

Deleted: of energy standpoint,

Deleted: should have

Deleted: cost of energy characteristics

Deleted: <sp>

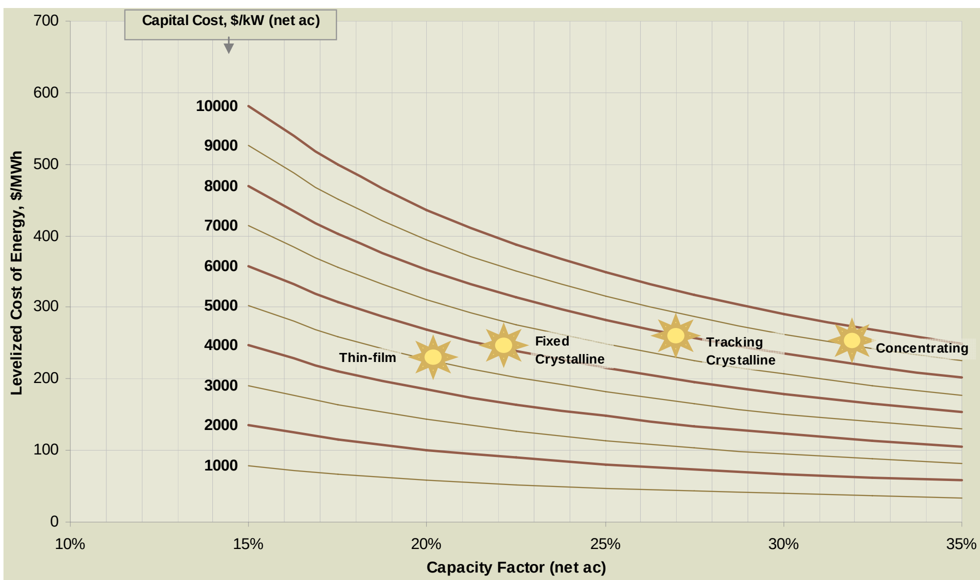


Figure 5-9. Comparative Cost of Electricity for Photovoltaics.

5.6.3 Environmental Impacts

The damming of rivers for small- and large-scale hydroelectric applications may have significant environmental impacts. One major issue involves the migration of fish and disruption of spawning habits. For dam projects, one of the common solutions to this problem is the construction of "fish ladders" to aid the fish in bypassing the dam when they swim upstream to spawn.

A second issue involves flooding existing valleys that often contain wilderness areas, residential areas, or archeologically significant remains. There are also concerns about the consequences of disrupting the natural flow of water downstream and disrupting the existing ecosystems.

The impacts of individual hydropower projects vary based on whether the project involves new dam construction or retrofits of existing dams (incremental). The resource assessment section of this report is restricted to upgrades of existing sites or adding generation to dams that currently do not have generation. No new dams are included.

Table 5-8. Hydroelectric Technology Characteristics.

Type	**New**	**Incremental**
Performance		
Typical Duty Cycle	Varies with Resource	Varies with Resource
Net Plant Capacity (MW)	<50	1 to 600
Capacity Factor (percent)	40 to 60	40 to 60
Economics ($2008)		
Total Project Cost ($/kW)	2,500 to 4,000	600 to 3,000
Fixed O&M ($/kW-yr)	5 to 25	5 to 25
Variable O&M ($/MWh)	5 to 6	3.5 to 6
Levelized Cost of Energy ($/MWh)	57 to 136	10 to 98
Applicable Incentives	$20/MWh PTC – No dams or impoundments; 150kW – 5MW	$10/MWh PTC
Technology Status		
Commercial Status	Commercial	
Installed U.S. Capacity (MW)*	99,000	

Formatted: English (U.S.)

Formatted Table

5.8.3 Cost and Performance Characteristics

Geothermal power is generated in three kinds of plants: flash steam, dry steam and binary. In the first two, the steam is supplied directly to the turbine generator, and water is injected back into the ground. In a binary power plant, a working fluid is passed through a heat exchanger, where it is heated by the geothermal fluid to its boiling point. The vapor passes through the turbine generator and condensed to be re-used again. Both the working fluid and the geothermal fluid are kept in separate, sealed loops. After its heat is transferred to the working fluid, the geothermal fluid is injected back into the ground.

For representative purposes, a binary cycle power plant is characterized in Table 5-10 Capital costs of geothermal facilities can vary widely for several reasons, but one of the most important variables is the drilling cost to develop the resource. First, exploration wells must be drilled to find and prove the resource; there are almost always one or two "dry holes" (those that do not provide commercially attractive temperatures and/or flow rates) drilled during this process. Once defined and proven, the development wells (production and injection) are drilled. Well costs increase non-linearly with depth, so the geologic controls on the geothermal system need to be well-understood (as a result of the exploration drilling program) to arrive at accurate cost estimates. However, because the "fuel supply" is developed up-front, fuel price risks are non-existent. This, combined with the high availability of geothermal projects (typically more than 95 percent) makes geothermal attractive for baseload generation and managing portfolio risk.

Based on data reviewed by Black & Veatch, the capacity factor range shown in the table is representative of binary cycle plants. Air-cooled binary cycle plants are particularly susceptible to reduced output during hot summer days, which reduces annual capacity factor. Flash-based geothermal plants should be expected to have higher capacity factors. Specific capacity factors will be determined for each geothermal project in Phase 1B.

Deleted: two

Deleted:

Deleted: former

Deleted: produced geothermal fluid is separated into steam and water phases; the

Deleted: the separated

Table 5-10. Geothermal Technology Characteristics.

Performance	
Typical Duty Cycle	Baseload
Net Plant Capacity (MW)	30
Capacity Factor (percent)	70 to 90
Economics (2008$)	
Total Project Cost ($/kW)	3,000 to 5,000
Variable O&M ($/MWh)	25 to 30
Levelized Cost ($/MWh)	54 to 107
Applicable Incentives	$20/MWh PTC, 5-yr MACRS
Technology Status	
Commercial Status	Commercial
Installed US Capacity (MW)	2,534

Deleted: 2007

5.8.4 Environmental Impacts

Binary geothermal development has relatively few environmental impacts. As with any power project, land area must be set aside for the power plant, substation and power lines. Some road access into remote areas may be required. Areas disturbed for exploration activities, drilling and pipelines are typically restored and re-vegetated. Although geothermal fluids contain small quantities of non-condensable gases, the power plants are designed to either remove them or keep them in solution to be reinjected underground. Owing to strict well design guidelines, there is no pollution of surface or groundwaters. Geothermal power plants with modern emission control technologies have minimal environmental impact. They emit less than 0.2 percent of the CO2, less than 1 percent of the SO2, and less than 0.1 percent of the particulates of the cleanest fossil fuel plant.

There is the potential for geothermal production to cause ground subsidence. However, proper resource management (most importantly including an effective injection strategy) mitigates this risk.

5.9 Marine Current

Marine renewable energy is still in early stages of concept design and development in comparison to other established renewable energy options. A number of large scale devices have been tested in the offshore environment; however there have currently been no commercial installations.

Extraction and conversion of tidal energy is not a new concept; for thousands of years humans have been harnessing the energy of the tides. In the more recent past, focus has been directed towards tidal barrage technology, which has been used in some locations globally, and has the potential to produce significant amounts of power. Environmental concerns have diminished the attractiveness of the tidal barrage concept however, at least in Europe and most western countries. In recent times there has been a significant increase in the research and development of tidal stream and marine current energy technologies.

5.9.1 Resource

Tides are the result of the interaction of the gravitational forces between the seas and the primary astronomical bodies in our solar system. Hundreds of components have been identified that affect the tides and therefore an exact tidal cycle for a specific site is very complex. The principal tidal harmonic is produced by the gravitational forces associated with the Moon and the Sun. The interaction between tidal harmonics at a site gives a predictable pattern over time. The advantage of tidal stream energy over say wind, wave or solar is this predictability.

The tides that are experienced are a result of the natural balance between the energy generating forces and the energy dissipating forces. The latter forces are largely dependent on bathymetry, and the nature of the sea-bed (e.g. particle sizes and presence of sand waves), but also depend on temperature, salinity etc.

Significant tidal stream currents generally occur where large tidal flows are forced through relatively narrow boundaries. Thus both high tidal ranges and narrow channels are generally required to cause significant tidal stream currents. However, due to local site conditions a high tidal range does not always indicate high tidal currents and similarly low tidal ranges do not always indicate low tidal currents.

Deleted:

Although no detailed assessment of the Global resource has been completed and therefore the results cannot be guaranteed, a number of studies have estimated the resource. Black & Veatch in their study for the Carbon Trust on resource summarized all the available data. The estimates range from 5TW, Isaacs and Seymour, 450GW from Blue Energy (developer) and ~25GW the UK Carbon Trust. The vast resource which is available Globally and in the US is discussed later in this report however this potential prize is important to consider when looking at future renewable energy options and therefore has been included in the review of the West Coast.

This section of the report considers what resource there is available that could be utilised for the development of marine renewable energy, specifically tidal stream energy. Marine renewable energy is still in an early stage of development in comparison to other established renewable energy options. A number of large scale devices have been tested in the offshore environment; however, there have as yet been no commercial installations. Although no detailed assessment of the global resource has been completed and therefore the results cannot be guaranteed, a number of studies have estimated the resource. Black & Veatch in their study for the UK's Carbon Trust on resource summarized all the available data. The estimates range from 5TW from Isaacs and Seymour, 450GW from Blue Energy (developer), and ~25GW from the Carbon Trust. The resource which is available globally, and in the US, is discussed later in this report; however, this potential prize is important to consider when looking at future renewable energy options and it has therefore been included in the review of the West Coast.

5.9.2 Applications

The four main categories that characterize tidal stream devices currently under development, as determined by the "prime-mover" (or principle defining characteristic) are as follows:

- Horizontal Axis Axial Flow Turbine (HAA)
- Vertical Axis Cross Flow Turbine (VAC)
- Oscillating Hydrofoil (OH)
- Venturi Devices (V)

The mechanical energy from the prime-mover may be converted to electricity via a number of conversion steps (e.g. hydraulic, direct electrical, mechanical) embodied in a "power-train".

There are in the region of 50 developers worldwide at varying stages however it is beyond the scope of this project to describe them all therefore; however, a couple of examples of horizontal axis axial flow (HAA) turbines are included - which have both been tested offshore.

Clean Current

Clean Current have been developing tidal technology for 6 years. Their tidal stream device is a bi-directional ducted horizontal axis turbine. It has a direct drive variable speed permanent magnet generator and therefore only incorporates one moving part. The support type is not specified although, as the device is fully submerged, it is likely to be a monopile, support frame, or gravity base.

Since inception, Clean Current has followed a defined development plan, which began with the testing of two prototypes in 2002 and 2003 which were used to validate the concept. In 2006 a 65kW (1/20th Scale prototype), see Figure 5-13, was installed in 22m depth of water and tested in the Clean Current Race Rocks demonstration project in

Canada. After 2 months of testing the control system was connected and power supplied to the battery. The Race Rocks project validated the duct design, the blade design, and the generator performance. However the hydrodynamic bearing system did not live up to expectations and will be replaced by a new system during the next phase of the project. This phase will involve reinstalling the 65kW device at Race Rocks in 2008 with a new bearing system and other minor improvements.

In 2009 Clean Current plan to install a 1.2MW device commercial scale device.

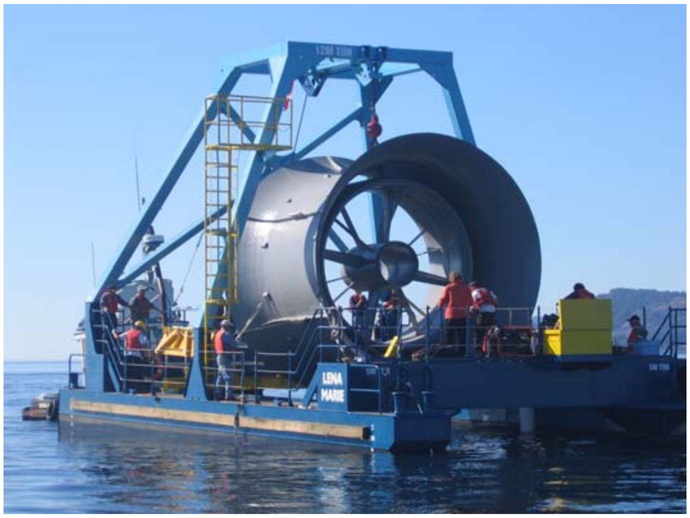


Figure 5-13. Clean Current.

Marine Current Turbines - Seagen

The Marine Current Turbines (MCT) “Seagen” device is a commercial demonstrator that has twin axial flow rotors, between 15 and 20m in diameter (refer to Figure 5-14) which drive the generator (via a gearbox). Each rotor consists of two blades which are pitch controlled to optimise the efficiency of the device. The rotors are fixed onto a horizontal bridge which is attached to a surface piercing monopile and the movement of the bridge up and down the monopile allows the rotors to be raised and lowered for maintenance.

Marine Current Turbines (MCT) installed a 300kW prototype tidal turbine device known as “Seaflow” in May 2003 off Lynmouth, Devon, UK. This was the world’s first tidal stream powered device of such size and power rating to be installed in an offshore location. Using experience fostered from the prototype Seaflow device, MCT were able to develop the more advanced, commercially focused Seagen device. The main objective of Seagen is to test the components of the twin rotor machine and verify the performance and engineering integrity of the concept at commercial scale.

Seagen was due to be grid connected in late 2006 in Strangford Narrows, Northern Ireland. However this was initially delayed until August 2007. There has been a further recent delay due to problems with the jack-up barge that was proposed to be used, and MCT are now planningsummerexpecting to install in early-mid 2008.

Interestingly, Marine Current Turbines have recently signed an agreement with Npower Renewables (one of the UK utilities) to form a company called SeaGen Wales. SeaGen Wales will install 10.5MW of generating capacity off the coast of Wales which will be commissioned by 2012.

Deleted:

Figure 5-14. Marine Current Turbines, SeaGen.

Environmental Impacts

Utilization of tidal stream energy for power generation has the environmental advantage of being a zero emissions technology, and is generally not considered to be environmentally harmful. However there are some concerns, including the amount of extractable energy from a tidal stream (i.e. the amount of energy which can be extracted without causing detrimental environmental impacts), or and potential impacts on marine mammals - although a $4million study into the impacts of the commercial scale SeaGen device will be carried out to assess the impacts on mammals when installation occurs in Strangford Lough, Northern Ireland during 2008. In addition, possible adverse visual impacts are highlighted by those who oppose the technology. A strategic environmental assessment has been completed in Scotland which investigated the generic impacts. The aim of this is to substantially reduce the time, effort, and expense for each developer when complying with requirements for development licenses.

5.9.3 Cost and Performance Characteristics

Table 5-11 provides typical characteristics for a 100 MW tidal farm. Generic data has been provided at this stage due to the lack of commercially available technology today. This data has been correlated by Black & Veatch against the most up to date costs for the most developed technologies. Capital costs will vary substantially with for example, size of farm installed, the specific site characteristics, the distance to grid, and the type of technology. It is expected that the cost of tidal stream farm development will decrease with improved concepts and optimized designs, economies of scale, and learning in production, construction, installation, and O&M.

Deleted: &V

Table 5-11. Instream Tidal Technology Characteristics.

Type	Generic offshore
Performance	
Typical Duty Cycle	As Available
Net Plant Capacity (MW)	100
Capacity Factor (percent)	25 to 45
Economics ($2008)	
Total Project Cost ($/kW)	2,200 to 4,725
Fixed O&M ($/kW-yr)	90 to 255
Variable O&M ($/MWh)	Incl. in FOM
Levelized Cost of Energy ($/MWh)	71 to 353
Applicable Incentives	
Technology Status	
Commercial Status	Development and testing
Installed U.S. Capacity (MW)	Not applicable

Formatted: English (U.S.)

5.10 Wave

Serious research into the use of wave energy as a viable form of power generation dates back to the 1970s with a large number of Wave Energy Converter (WEC) devices having been developed since. Indeed, a recent categorization study undertaken by Black & Veatch shows that there could be as many as 720 unique techniques in which to extract and convert wave energy. There have been over 100 patents issued for different WEC devices which give an indication as to the large array of potential technology in the wave energy industry.

Deleted: &V

5.10.1 Applications

Serious research into the use of wave energy as a viable form of power generation dates back to the 1970s with a large number of Wave Energy Converter (WEC) devices having been developed since. Indeed, a recent categorization study undertaken by Black & Veatch shows that there could be as many as 720 unique techniques by which to extract and convert wave energy.

Deleted: &V

There are five key design parameters, each containing a number of internal classification groups, that describe a WEC. The design parameters are as follows:

- Configuration
- Working Surface
- Reaction
- Mode
- Energy Transfer

Using these parameters to identify types of wave devices becomerapidly becomes complex, and therefore the proximity to shore is more commonly used to distinguish them. In the first instance, onshore devices can be seen as attractive solution by the wave energy industry given that power transmission issues and maintenance access are straightforward to resolve whilst large waves forces may be avoided. However, the main disadvantage with an onshore device is that their construction is highly dependent on local conditions whilst the available wave energy is generally significantly lower at the shoreline due to energy dissipating processes. Moreover, the visual impact of such devices could be seen as an adverse impact on the surrounding environment – which can result in many difficulties to overcome. By considering these issues, the wave energy industry and device developers have generally steered away from onshore devices and have focused on offshore deployment. As a result, there are only a handful of onshore devices currently under development.

The term "near-shore" is not precisely defined in the marine renewable industry yet, and is often described as the area that is neither offshore nor onshore. In this report, Black & Veatch has decided to consider a WEC to be located "near-shore" if the energy converter is in the sea but its generator and substation are located on the shore. Compared to offshore devices, the advantages are maintenance and submarine cable length, but there is not as much power close to the shore as offshore. Most of the developers, even if their first concept were designed for near-shore, tend to develop new designs to go fully offshore.

Deleted: &V

To access the more powerful waves in deepwater, WECs need to go offshore. The main disadvantage is that the device is then situated in a very harsh ocean environment,

Table 5-13. Renewable Technologies Performance and Cost Summary.

	Net Plant Capacity, MW	Net Plant Heat Rate, Btu/kWh	Capacity Factor	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Fuel Cost, $/MBtu	Levelized Cost, $/MWh
Solid Biomass	35	14k to 17.5k	80	3000 to 4500	83	11	0 to 3	67 to 140
Cofired Biomass	35	10000	85	300 to 500	5 to 15		-0.5 to 1	-1 to 22
An. Digestion	0.15	13000	80	4000 to 6000		17	1 to 3	100 to 168
Landfill Gas	5	13500	80	1200 to 2000		17	1 to 2	50 to 80
Solar Thermal	200		26 to 29	3800 to 4800	66			143 to 192
Solar Photovoltaic	20		25 to 30	6500 to 7500	35			201 to 276
New Hydroelectric	<50		40 to 60	2500 to 4000	5 to 25	5 to 6		57 to 136
Inc. Hydroelectric	1 to 600		40 to 60	600 to 3000	5 to 25	3.5 to 6		10 to 98
Wind	100		25 to 40	1900 to 2400	50			59 to 128
Offshore Wind	200		35 to 45	5000 to 6000	75-100			142 to 232
Geothermal	30		70 to 90	3000 to 5000		25 to 30		54 to 107
Marine Current	100		25 to 45	2200 to 4725	90 to 255			97 to 410
Wave	100		25 to 45	2800 to 5200	150 to 270	11		135 to 445

Notes:

Levelized cost is the levelized cost of generation only. Includes applicable incentives, subsidies, etc.

Break-outs for fixed and variable are arbitrary and not consistent across technologies. When no value is shown for one O&M category, it is assumed that the other O&M category includes all O&M costs.

Deleted: 14500
Deleted: 5000
Deleted: 150
Deleted: -
Deleted: 3600
Deleted: 4200
Deleted: 137
Deleted: 176
Deleted: -
Deleted: Cost includes

5.11.1 Relative Costs

Figure 5-18 shows the range of levelized cost of generation for all the technologies included in this section. The lowest levelized cost of energy is that of biomass cofiring and incremental hydroelectric power. These projects enjoy low capital cost from "piggybacking" on existing projects and have high capacity factors. Landfill gas, geothermal and new hydroelectric projects are also able to divide their costs over a greater number of megawatt hours due to their baseload mode of operation. Wind energy is low cost for renewables, but the relatively low capacity factor means less generation to dilute the costs. The marine technologies are not able to benefit from federal tax subsidies. The solar technologies and offshore wind are hit with both high capital costs and relatively low annual generation totals.

While the cost ranges shown in Figure 5-18 are very broad, Phase 1B will develop more specific estimates for each renewable energy project location or resource class (for out-of-state resources). It is important to note that the levelized cost of generation is only one component of the resource valuation process. The others include transmission cost, energy value, and capacity value.

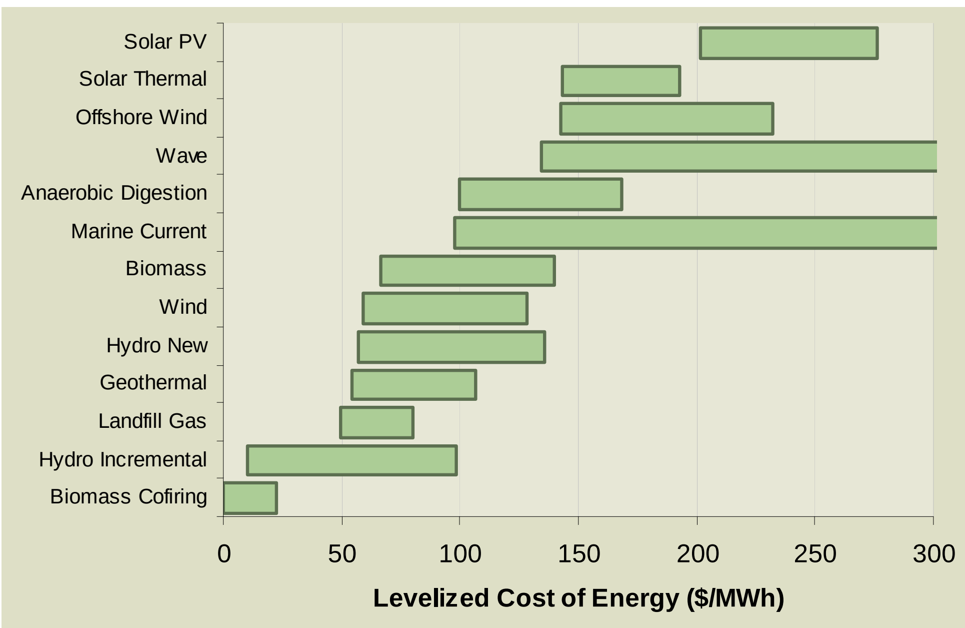


Figure 5-18. Typical Levelized Cost of Generation ($/MWh).

6.0 Resource Screening

This section evaluates the resource for each renewable energy technology. In each case, an assessment is made of the total technical potential for the technology over the RETI study region, and the total resource is then screened for technical and environmental viability. Ultimately, recommendations are developed for each technology regarding recommended resource areas for further analysis.

Deleted: of study

It should be noted that this resource screening process is preliminary and is not intended to indicate that all of the potential identified could actually be developed. In particular, in Phase 1B a more detailed environmental screening process will be undertaken for all resources in collaboration with the Environmental Working Group.

6.1 Solid Biomass

Direct-fired biomass (i.e., stand-alone biomass combustion) has been identified as a promising technology for the RETI Phase 1 study. Biomass cofiring is generally more economical than stand-alone biomass facilities, but cofiring is limited to locations where biomass is available near an existing coal plant. If there are no coal plants in the region of interest, biomass cofiring is not a viable option. Due to the lack of possible host facilities for cofiring in the Phase 1 study area, direct fired biomass has been identified as the conversion method for solid biomass. This section presents the methodology used to quantify (at a high level) biomass resource availability and the potential for biomass-derived electrical generation throughout the RETI study region.

6.1.1 Biomass Methodology

Biomass-derived electrical generation potential is based on available biomass resources. The quantification of biomass resources presented here relies primarily on assessments developed by national laboratories, state agencies, and university research centers. The resource information presented in this study has been utilized to identify the most promising areas for development of biomass power projects. To determine the actual available quantities and suppliers of biomass material in the region, a more detailed resource assessment considering fuel price economics is necessary. This will be undertaken in Phase 1B.

To obtain an overview of the biomass resources available across the entire RETI study region, the most recent national biomass resource assessment developed by the National Renewable Energy Laboratory (NREL) was reviewed. In December 2005, NREL published a new set of biomass resource data and documentation, including GIS

It is important to note that NREL's estimates are for sustainable harvesting of biomass and not activities such as clear-cut logging.

For each of the regions considered in this study, other state and province assessments were reviewed and compared to the NREL data and methodology. These assessments were typically more focused than the NREL study, and, with some exceptions, the findings of these studies were in general agreement with the NREL assessment. In general, these studies quantified the total biomass resources available for the generation of electricity and did not account for any existing utilization of biomass for power generation or competing uses. This methodology is similar to that of the NREL study, which allows for comparison of the studies. An exception to this is the assessment reviewed for Oregon, which identified resources in excess of existing utilization.

High-level biomass resource assessments for each of the states and provinces in the RETI study region are presented in the following sections. Considering the resources identified and the existing biomass-derived generation within the RETI study region, additional biomass-derived generation potential is estimated for each state and province.

6.1.2 California Biomass Potential

Biomass has been identified as a priority in California. The Governor of California has signed an executive order (S-06-06) that sets a state policy goal of maintaining biomass and biogas production at 20 percent of total renewables. Although this would require a significant increase from current production, it appears the state has the resources to support this expansion. While not as large as the potential for wind and solar generation, there is significant potential for biomass-derived generation in California. Biomass resources are fairly well distributed throughout the state. Agricultural residues are prevalent throughout the Central Valley, while forestry residues are concentrated primarily in the northwestern counties of the state, such as Humboldt, Mendocino, Siskiyou, and Trinity. There are significant quantities of biomass in the municipal solid waste streams associated with metropolitan areas, particularly Los Angeles.

California's biomass resources as estimated by NREL are listed in Table 6-1. NREL estimates that nearly 12 million dry tons of biomass are available per year in California for the generation of biomass-derived electricity. Table 6-1 also lists the generation capacity that could theoretically be supported by the estimated resources within each county. This estimate of potential generation assumes a biomass heating value of 8,500 Btu/lb, a facility heat rate of 14,500 Btu/kWh and a facility capacity factor of 80 percent.

assessment utilized actual crop production data, actual timber harvest data, actual waste disposal data, and other "actual" data. It is important to note that the CBC estimate does not consider economics; it is strictly an estimate of technical potential and not commercial potential.

The quantities of biomass resources considered technically viable for collection by the CBC in 2010 are listed in Table 6-2. CBC estimates that there are more than 31 million dry tons of biomass available per year in California for the generation of biomass-derived electricity. Table 6-2 also lists the CBC estimate of generation capacity that could be supported by the estimated resources within each county.

There are significant disparities between the NREL and CBC biomass resource assessments. The CBC estimates are approximately 200 to 300 percent higher than the NREL estimates in every category (i.e., agricultural residues, forestry/wood products residues, and urban wood waste). The estimates of statewide generation potential from the NREL assessment and the CBC assessment are 2,000 MW and 4,900 MW, respectively. Due to the utilization of local production and disposal data for the CBC assessment rather than national databases (as utilized in the NREL assessment), the CBC estimates are considered more reliable than the NREL estimates. The individual components of this data set will likely require further review in Phase 1B to reconcile differences with the NREL estimate. In addition, it is important to ensure that the resources identified are sustainable. For example, residues from forest thinnings are not universally accepted as a sustainable biomass fuel. In Phase 1B, Black & Veatch plans to coordinate with the Environmental Working Group and biomass interests to ensure the resources included in the project identification process are environmentally sound.

Regardless of whether the generation potential in California is 2,000 MW or 4,900 MW, there is substantial potential for increased biomass utilization to generate electricity. Currently, the total operational biomass generation capacity in California is about 700 MW.[18] The potential for additional biomass power in California is promising. Due to the dispersed nature of biomass resources in the state of California, there are likely several locations in the state that could support a biomass-fired facility from a technical perspective. The most viable biomass facilities would likely be:

- Wood-fired facilities in northern California (i.e., Humboldt, Mendocino, Siskiyou, and Trinity counties)
- Facilities in the Central Valley fueled with agricultural residues
- Facilities near urban areas fueled with urban wood waste

---

[17] Williams, et al. "An Assessment of Biomass Resources in California, 2006," 2006. California Biomass Collaborative Draft Report. Accessed online at: http://biomass.ucdavis.edu/reports.html on February 28, 2008.

[18] Source: Black & Veatch query of Ventyx Energy Velocity database, March 11, 2008.

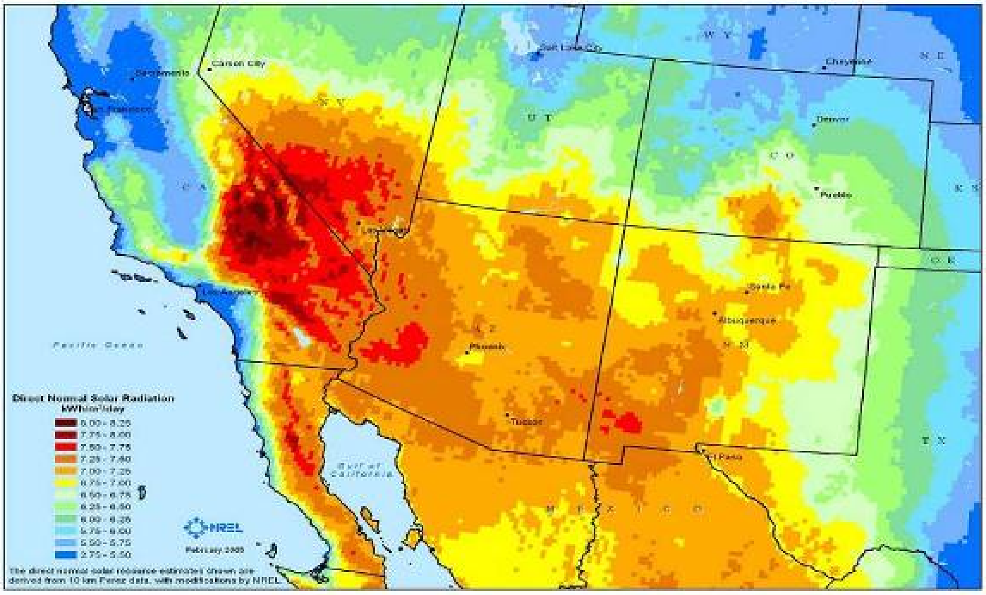


Figure 6-2. Direct Normal Radiation in the Southwest (NREL).

NREL performed a comprehensive solar resource assessment of the southwestern US, using satellite data and GIS mapping. NREL has performed additional analysis on the solar data sets for the Concentrating Solar Deployment System (CSDS) model. The results of this work are a tabulation of solar potential on square kilometers of land by solar class for 32 supply regions across the US southwest. In performing its assessment Black & Veatch assumed that 25 MW of solar capacity could be developed per square kilometer of land (10 acres per MW).[28] This is an intentionally conservative footprint used only for resource valuation. Projects in RETI Phase 1B will be assigned footprints appropriate to the details of the project.

Deleted: a typical

Deleted: solar trough plants, the proxy solar thermal technology

Not all land in the US can be considered available for solar development, even if it has favorable levels of direct sunlight. DOE and NREL have developed standard "exclusions" for excluding land that may not be suitable for solar development. The key exclusion is for land greater than 1 percent slope. Land with higher slope is considered uneconomic for solar thermal development due to the high cost of civil works required to terrace or level the land.[29] The NREL exclusions also include environmental considerations, such as urban areas, national parks, wetlands, and other sensitive areas. These exclusions ensure that this resource assessment considers the viability of development of the resource to some degree. The next phase of RETI will use a more

Deleted: the analysis uses realistic assumptions about where solar power can be

[28] NREL assumes a more aggressive 50 MW per square kilometer.
[29] Solar thermal technologies other than trough may be able to use land with greater than 1 percent slope.

detailed set of screening criteria developed by RETI's Environmental Working Group. NREL's standard land exclusions are shown in Table 6-16.

Table 6-16. Standard NREL Land Exclusions.

Criteria	Rationale
< 6.75 kWh/m2/day annual average direct normal resource (May 2003 Perez data).	Resources below class 1 are generally not economic for utility-scale power generation.
> 1 percent* slope (derived from 90 m elevation data)	Expensive to construct facilities on areas of high slope.
In major urban or water features	Unsuitable for renewable development.
In protected federal lands (wilderness, parks, monuments, etc.)	Assumed to be environmentally or culturally sensitive lands.
Remaining resource is not at least 5 contiguous sq. km.	Difficult to construct facilities on small, non-contiguous land areas
Source: NREL. * up to 3% slope may be acceptable for advanced solar thermal technologies.	

Deleted: .

The value of the CSDS analysis for RETI is that it is recent and it provides a consistent basis of comparison for solar potential across most of the region of study. However, there are several shortcomings in this dataset. First, the solar maps are based on satellite data and atmospheric models and may not match actual solar radiation. Additionally, these estimates represent theoretical or technical potential and are not bound by site-specific constraints such as transmission capacity, constructability, environmental restrictions, or cost. The RETI Phase 1B analysis will include site-specific assessment of the developable potential for solar in the favorable areas identified in Phase 1A. Thus, Phase 1B will identify a much smaller set of resources that could potentially be built and financed in the next decade.

The following sections provide a broad overview of the available potential for solar thermal energy in each state within the RETI study area. Where possible, CSDS data is summarized by CSDS region to show the technical potential of solar development in the western United States. Exceptions are for British Columbia, Oregon, and Washington. Much of the solar resource in these three areas is considered to be less than class 1, and therefore non-economic.

6.4.2 California Solar Potential

Most of California's solar potential is concentrated in southern California. Southern California contains more than 17,600 square kilometers of very flat (less than 1 percent grade) land with class 2 and greater radiation; these solar resources are considered potentially economic. The majority of California's solar potential is located investment tax credits and are thus not expected to be competitive with US-based resources.

6.4.6 Solar Thermal Summary

Solar thermal resources in the RETI study region are summarized in Table 6-21. There is superb solar thermal resource available in southern California, southern Nevada, and western Arizona. These three regions combined have roughly 933 GW of class 2 or better solar resource potential. Clearly, solar thermal development is not limited by the availability of resource. The solar thermal resources already under development in southern California, as indicated by BLM applications and the ISO queue, could easily fill the California RPS needs twice over.

The RETI Phase 1A study recommends including solar thermal resources in California, southern Nevada, and western Arizona for further study in Phase 1B. While Southern California has ample resources for solar thermal development, there is also development in southern Nevada and Arizona planned for the California market.

Table 6-21. Summary of Solar Thermal Resources.

	Potential, MW*	Assess in Phase 1B?	Notes
Arizona	316,628	Yes	Western Arizona only
Baja California	**	No	No ITC
British Columbia	0	No	Resource not viable for power production
California	439,948	Yes	
Nevada	172,181	Yes	Southwestern Nevada only
Oregon	0	No	Resource not viable for power production
Washington	0	No	Resource not viable for power production
Grand Total	928,397		

Notes:
* Nameplate capacity, Class 2 and higher.
** Estimates for Baja California were not available.

Deleted: 443,799

Deleted: 932,608

6.4.7 Data Sources

Data sources used in this analysis included:

- NREL Insolation Maps, available at http://www.nrel.gov/csp/maps.html
- George Simons and Joe McCabe, "California Solar Resources" California Energy Commission, CEC-500-2005-072 April 2005.

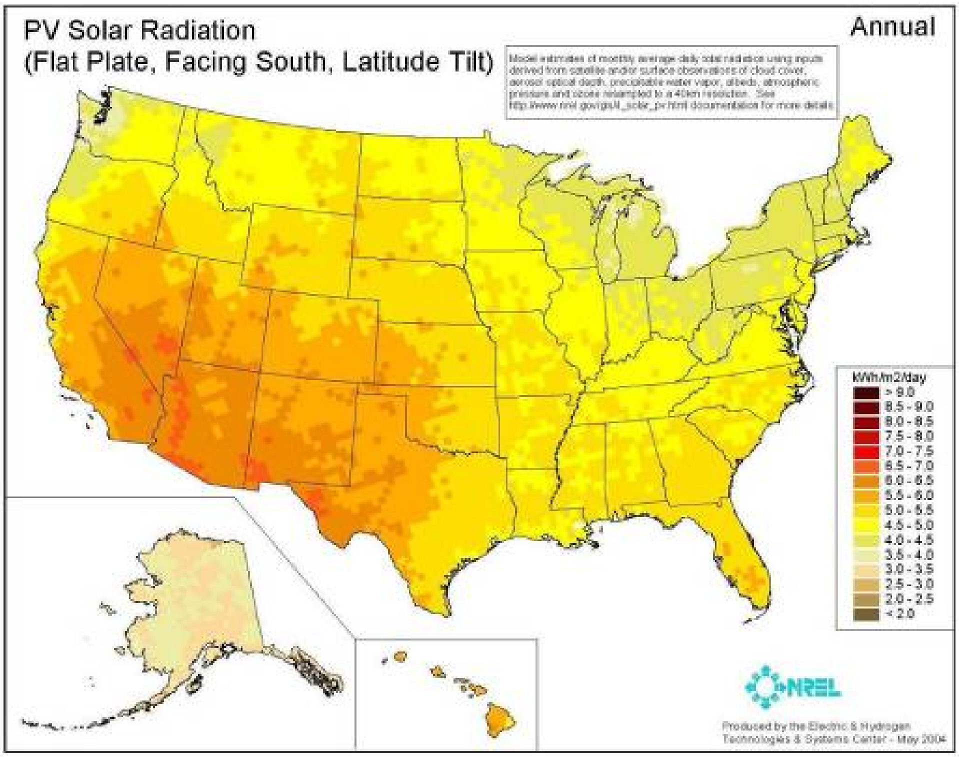


Figure 6-7. US Solar Resource for Photovoltaics (NREL).

Deleted: photovoltaics

A 2005 CEC study found there to be close to 17,000 GW of solar photovoltaic technical potential in the state, an enormous number. As with solar thermal, solar photovoltaics are clearly not limited by resource availability.[30]

While neighboring regions also have good solar resources, Black & Veatch does not recommend out-of-state solar PV resources be considered in Phase 1B. Because of the large, high quality resource available in California, it does not appear economical to consider building transmission to access out of state solar photovoltaic resources. Only specific out of state projects proposed for the export of energy to California will be included in RETI Phase 1.

Deleted: and the high cost of photovoltaics,

Deleted:

[30] George Simons and Joe McCabe, "California Solar Resources" California Energy Commission, CEC-500-2005-072 April 2005.

6.6 Hydroelectric

This section presents the methodology used to evaluate the developable hydropower resources and provides an overview of hydropower resource availability throughout the RETI region of study.

6.6.1 Resource Availability

A hydroelectric resource can be defined as any flow of water that can be used as a source of kinetic energy. Projects that store large amounts of water behind a dam can regulate the release of water through turbines and generate electricity regardless of the season. These facilities can generally serve baseloads. Run-of-river projects do not impound the water, but instead divert a part or all of the current through a turbine to generate electricity. At run-of-river projects, power generation varies with seasonal flows and can sometimes help serve summer peak loads.

All hydroelectric projects are susceptible to drought. In fact, the variability in hydropower output is rather large, even when compared to other renewable resources. Based on analysis of reported data from Global Energy Decisions, in 2006 the aggregate capacity factor over time for all hydroelectric plants in the United States has ranged from an average high of 47 percent to an average low of 31 percent.

6.6.2 Methodology

Developable renewable hydropower resources are constrained by several factors:

- Water resources
- Regulatory definitions that define what types of hydro are considered renewable
- Environmental constraints

Black & Veatch considered all of these factors in assessing the hydropower resource for RETI, as described further below.

Water Resources

There are numerous undeveloped hydropower sites, including existing dams and others, within the RETI region. Hydropower potential has been previously assessed across the United States by The U.S. Department of Energy Idaho National Laboratory (INL) for the National Energy Strategy. The INL database served as the primary resource for this high level study for Arizona, California, Nevada, Oregon, and Washington. There are several references available from Canada to identify hydropower potential. One resource is the Canadian Renewable Energy Network (CanREN).

Deleted: provide

Deleted: In the United States, 23 states have some variation of RPS programs. RPS eligibility rules for hydro vary state-by-state. The California definition of eligible renewable resources includes small hydropower (30 MW or less) as eligible for contributing toward the RPS. New hydropower facilities are not eligible if they require new and or increased appropriation of water.¶
There are several existing dam sites in the RETI region with additional hydropower potential identified by the United States federal government. The U.S. Department of Energy Idaho National Laboratory (INL) provides this information as part of the National Energy Strategy. The INL database served as the primary resource for this high level study for Arizona, California, Nevada, Oregon, and Washington. The Project Environmental Suitability Factor (PESF) developed by INL rates potential sites in one of five categories. For the purpose of this study, only projects identified in the INL database with a 0.90 PESF (0.9 = environmental concerns have little effect on likelihood of development) were considered. Further, per the requirements of the RPS eligibility rules, only sites less than 30 MW were considered.¶
There are several references available from Canada to identify hydropower potential. One resource is the Canadian Renewable Energy Network (CanREN). CanREN provides this information to identify additional hydropower potential in Canada. CanREN was created through the efforts of Natural Resources Canada (NRCan).¶
The website of Mexico's federal Power Agency, the Comision Federal de Electricidad (CFE), was used to assist in identifying potential hydropower sites in the northern region of Baja California as well as other publicly available documents and reports.¶
<#>Resource Availability¶
A hydroelectric resource can be defined as any flow of water that can be used to capture the kinetic energy. Projects that store large amounts of water behind a dam can regulate the release of water through turbines and generate electricity regardless of the season. These facilities can generally serve baseloads. Run-of-river projects do not impound the water, but instead divert a part or all of the current through a turbine to generate electricity. At run-of-river projects, power generation varies with seasonal flows and can sometimes help serve summer peak loads. ¶
All hydroelectric projects are susceptible to drought. In fact, the variability in hydropower output is rather large, even when compared to other renewabl ... [3]

CanREN provides this information to identify additional hydropower potential in Canada. CanREN was created through the efforts of Natural Resources Canada (NRCan). In conjunction with CEA Technologies Inc., NRCan has posted its information in the International Small-Hydro Atlas. The website of Mexico's federal Power Agency, the Comisión Federal de Electricidad (CFE) and other public sources were used to identify potential hydropower sites in the northern region of Baja California.

Regulatory Constraints

RPS eligibility rules for hydro are inconsistent. The California definition of eligible renewable resources includes hydropower as category, but California has additional eligibility rules that significantly restrict what types of hydro qualify as renewable. [31] For new facilities, generally, small projects (30 MW or less) are eligible for the RPS. However, new hydropower facilities are not eligible if they "cause an adverse impact on instream beneficial uses or cause a change in the volume or timing of streamflow". This restriction makes qualification of completely undeveloped sites difficult. For existing facilities, incremental hydropower generation qualifies for the RPS. Incremental generation is not limited to less than 30 MW, although only the increased output from the facility qualifies as renewable. There are restrictions on what qualifies as incremental generation, but generally incremental generation is the result of improved efficiency at the plant that does not impact streamflow.

Environmental Constraints

In addition to these regulatory constraints, there are also environmental constraints that reduce the developable hydro potential for the purposes of RETI. In assessing potential, Black & Veatch applied the following filters in the United States:

- The Project Environmental Suitability Factor (PESF) developed by INL rates potential sites in one of five categories. For the purpose of this study, only projects identified in the INL database with a PESF of 0.90 (0.9 = environmental concerns have little effect on likelihood of development) were considered.
- For new generation, Black & Veatch only included projects that involve adding power generation to an existing dam that has no generation. Construction of any new dams or diversions was not considered. As a result, all undeveloped hydropower sites were not included in this analysis.

[31] California Energy Commission, "Renewables Portfolio Standard Eligibility, Third Edition", January 2008, available at: http://www.energy.ca.gov/2007publications/CEC-300-2007-006/CEC-300-2007-006-ED3-CMF.PDF

Comparable information was not available in Canada and Mexico, so the estimates for these regions should be considered preliminary.

6.6.3 Types of Hydropower Facilities

Table 6-22 below summarizes by status of the potential dam sites. Sites identified as "with power" are sites that are currently generating hydropower and upgradeable through energy efficiency, improved control routines, etc. Sites identified as "without power" are sites that are developed (have a dam) but do not currently have hydropower facilities in place.

Table 6-22. Status of Hydroelectric Projects in the RETI Region.

	With Power	Without Power
Arizona*	0	0
Baja California**	0	0
British Columbia***	15	0
California*	2	51
Nevada*	1	5
Oregon*	1	8
Washington*	3	29
Total	7	93

Source:
*INL
** Comisión Federal de Electricidad
***International Small-Hydro Atlas (www.small-hydro.com). Information was not provided regarding existing generation or not. It was assumed existing projects had installed generation.

Figure 6-8 shows a summary of the potential for small hydropower development in the U.S. portion of the RETI study region. The rest of this section contains a brief summary of each region defined by the RETI project. In the following sections, development capacity is characterized both below 10 MW and greater than 10 MW. RETI is focused on sites greater than 10 MW. New generation sites are restricted to below 30 MW per the California RPS eligibility rules; incremental generation has no upper limit.

Deleted: There are four types of hydropower facilities that were examined this study. They are:¶
<#>Impoundment Hydropower - utilizes a dam to store water in a reservoir. Water can be released from the reservoir to generate electricity. ¶
<#>Run-of-River - utilizes the flow of water within a river, requiring very little or no impoundment. Run-of-River hydropower is typically designed for large flows with low head or small flows with high head.¶
<#>Microhydropower Projects - produce 100 kilowatts (kW) or less. Microhydropower plants can utilize low heads or high heads. ¶
<#>Diversion Hydropower – diverts a portion of river flows through a canal or penstock to generate electricity.¶
¶

Deleted: are assumed to be

Deleted: sites

Deleted: Sites identified as "undeveloped" do not have hydropower infrastructure in place and would require the greatest initial capital costs.

Formatted Table

Deleted: Dam

... [4]

Formatted Table

Deleted: Comision

Formatted: English (U.S.)

Formatted: English (U.S.)

Deleted: The rest of this section contains a brief summary of each region defined by the RETI project.

Deleted:

Deleted: <sp> ... [5]

6.6.4 California Hydropower Potential

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

California has an area of 158,693 square miles and an average annual rainfall of 17.3 inches. INL has identified California with a large hydropower potential. Table 6-23 shows the theoretical potential capacity from hydropower by county in California.

Table 6-23. California Developable Hydropower Technical Potential Per County.

Deleted: County ... [6]

County	Without Power		With Power		Total
	<10 MW	10-30 MW	<10 MW	>10 MW	
Alameda	3.1	12			15.1
Amador	4.5	10			14.5
Butte	1			32.6	33.6
Calaveras		10			10
Contra Costa	12.2				12.2
Fresno	4.5	24			28.5
Imperial	1.6				1.6
Inyo	8.6				8.6
Lake	11.3				11.3
Merced		25			25
Mono	9.2				9.2
Monterey	6.2				6.2
Nevada	6.3		2		8.3
Placer	9.2				9.2
Plumas	8.6	25.8			34.4
San Diego	2.6				2.6
Santa Clara	2.4				2.4
Santa Cruz	1.5				1.5
Shasta	3.3				3.3
Sierra	4.7	20			24.7
Siskiyou	4.4				4.4
Stanislaus	3.5				3.5
Trinity	11.3				11.3
Tulare	2.3				2.25
Total	**122.3**	**126.8**	**2**	**32.6**	**283.7**

Source: INL

For the state of California there is a total potential hydropower capacity of 283.7 MW, of which 159.4 MW have an estimated power generation greater than 10 MW. The greatest potential is shown in Butte County, which contains 34.4 MW of potential capacity.

Deleted: Of

Deleted: 92 identified sites, 22 are gravity diversion, 49 are run-

Deleted: -river, 1 is pumped diversion, and 20 are conventional

Deleted: with storage. There is a total potential

Deleted: 298

Deleted: 231

Deleted: a site potential between

Deleted: and 30

Deleted: Plumas

Deleted: 23.5

The southern portion of the state is generally known for its limited water resources. Because of this, California transfers relatively large quantities of water over large distances resulting in a significant portion of potential resources coming from numerous manmade conveyances.

Deleted: and this results

Deleted: large

6.6.5 *Arizona Hydropower Potential*

Deleted: Hydropower appears to be a good source of renewable energy for California. It is recommended that further investigation be carried out in Phase 1B of the larger project opportunities to identify site-specific costs and potential.¶

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

Arizona has relatively poor water resource availability with an area of 113,909 square miles and an average annual rainfall of 7.1 inches. To identify specific areas to the development of hydropower energy projects in Arizona, in September 2007 Black & Veatch produced a report for the Arizona Public Service Company, Salt River Project, and Tucson Electric Power Corporation entitled "Arizona Renewable Energy Assessment." Based on Arizona's Renewable Energy Standard (RES), the conclusion of this report found that of the projects identified, Glen Canyon was the only site greater than 10 MW. However, INL defines the Project Environmental Suitability Factor (PESF) for this project as 50 percent, so it is not included in this report.

Deleted: and Waddell were

Deleted: projects that could be reasonably identified; however,

Deleted: capacities are too large

Deleted: California's RPS.

Considering a PESF constraint of 90 percent, there is 14 MW of capacity potential identified by the INL database. However, these are all undeveloped projects that will not be considered due to the constraints previously established. As a result, Arizona are less than 10 MW in capacity. Table 6-24 identifies the locations of the potential hydropower resources in Arizona by county.

Deleted: Arizona has relatively poor water resource availability with an area of 113,909 square miles and an average annual rainfall of 7.1 inches and only

Deleted: INL. All of

Deleted: potential hydropower resources in

Table 6-24. Arizona Developable Hydropower Technical Potential Per County.

County	Total Capacity (MW)
Maricopa	8.2
Pima	4.3
Yuma	1.4
Total	13.9

Source: INL

Of the hydropower projects previously identified and studied by INL all does not have any hydropower potential that qualifies for RETI.

Deleted: a relatively small capacity in comparison to the total capacity of hydropower in the RETI region of study.¶
In summary, the hydropower resources in Arizona are relatively poor compared to other regions under study

Deleted: Arizona, projects are more likely to sell their output to local Arizona utilities to meet their state's RES than sell power to California.

6.6.6 Nevada Hydropower Potential

Nevada has an area of 110,540 square miles and a relatively dry climate with an average annual rainfall of 7.9 inches. Table 6-25 shows the theoretical potential capacity from hydropower by county in Nevada.

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

Table 6-25. Nevada Developable Hydropower Technical Potential Per County.

Deleted: County ... [7]

County	Without Power		With Power		Total
	<10 MW	10-30 MW	<10 MW	>10 MW	
Churchill	1.6				1.6
Elko			4.2		4.2
Pershing			1.5		1.5
Washoe			1.1		1.1
Total	**1.6**	**0**	**6.8**	**0**	**8.4**
Source: INL					

All the hydropower projects identified and studied by INL have a capacity of less than 10 MW. In comparison to the total capacity of hydropower in the RETI region of study, the potential for hydropower from Nevada is small.

In summary, Nevada does not have the natural resources required to develop any additional hydroelectric facilities, and therefore hydroelectric generation is not considered a future potential resource. Any Nevada projects are more likely to sell their output to local utilities to meet the state's RPS than sell power to California.

6.6.7 Oregon Hydropower Potential

Oregon has relatively good hydropower potential with an area of 96,981 square miles and an average annual rainfall of 37.4 inches. Table 6-26 identifies the location of the developable hydropower resources in Oregon, by county.

Table 6-26. Oregon Developable Hydropower Technical Potential Per County.

County	Without Power		With Power		Total
	<10 MW	10-30 MW	<10 MW	>10 MW	
Clackamas			5.8		5.8
Clatsop	1.6				1.6
Coos	1				1
Hood River	5.8				5.8
Jackson	9				9
Josephine	4.7				4.7
Lake	3.7				3.7
Total	**25.8**	**0**	**5.8**	**0**	**31.7**

Source: INL

Formatted Table

Of the 9 identified sites, 1 is run-of-river and 7 are conventional hydropower with storage. Of the hydropower projects previously identified and studied by INL all have a relatively small capacity in comparison to the total capacity of hydropower in the RETI region of study.

In summary, Nevada does not have the natural resources required to develop any additional hydroelectric facilities, and therefore hydroelectric generation is not considered a potential resource for Phase 1B. Any Nevada projects are more likely to sell their output to local utilities to meet the state's Renewable Portfolio Standard than sell power to California.

6.6.8 *Oregon Hydropower Potential*

Oregon has relatively good hydropower potential with an area of 96,981 square miles and an average annual rainfall of 37.4 inches. Table 6-27 identifies the location of the developable hydropower resources in Oregon, by county.

Table 6-27. Oregon Developable Hydropower Technical Potential Per County.

County	Total Capacity (MW)
Baker	7.2
Clackamas	41.9
Clatsop	1.6
Coos	1.0
Deschutes	5.7
Douglas	4.0
Hood river	7.8
Jackson	9.0
Josephine	7.7
Lake	3.8
Lane	4.0
Malheur	22.8
Marion	4.0
Umatilla	25.8
Total	146.3

Source: INL

Of the 9 identified sites, 1 is run-of-river and 7 are conventional hydropower with storage. There is a total potential capacity of 147 MW, of which 66 MW have a site potential between 10 and 30 MW. The greatest potential is in northern part of Oregon, which contains half of the identified developable hydropower resources. It is recommended that further investigation be carried out in Phase 1B of the larger project opportunities to identify site-specific costs and potential.

The state of Oregon has a total potential capacity of 31.7 MW, all of which are for sites with an expected generation less than 10 MW. Due to the small size of these upgrades, it is not recommended to pursue any future RETI hydroelectric projects in the state of Oregon.

6.6.9 Washington Hydropower Potential

Washington has good hydropower potential, with an area of 68,192 square miles and an average annual rainfall of 27.7 inches. Table 6-28 identifies the location of the developable hydropower resources in Washington, by county.

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

Field Code Changed

Table 6-28. Washington Developable Hydropower Technical Potential Per County.

County	Without Power		With Power		Total
	<10 MW	10-30 MW	<10 MW	>10 MW	
Benton	1.4				1.4
Chelan	6				6
Clallam	12				12
Cowlitz		21.5			21.5
Douglas				314	314
Franklin	5				5
Grays Harbor	3.3				3.3
Jefferson	3				3
King		10		10	20
Klickitat				540	540
Mason	5.2				5.2
Pend Oreille		49			49
Pierce	1.1				1.1
Spokane		15			15
Stevens	2.9				2.9
Wahkiakum		17			17
Whatcom	4.5				4.5
Yakima	10	10			20
Total	**58.3**	**122.6**	**0**	**864**	**1044.9**
Source: INL					

Deleted: County ... [8]

The state of Washington has a total potential capacity of 1045 MW, most of which of which is based on two existing hydroelectric projects (John Day and Grand Coulee) with a combined increase in capacity (or efficiency enhancements) of 864 MW. While these two projects show substantial potential, they are unlikely to qualify for the California RPS for other reasons. This is because the output would likely not be sold to an IOU under a long-term contract. Excluding these two projects, there is a total of 132.6 MW that could be developed in Washington for the purposes of RETI.

6.6.10 Baja California Hydropower Potential

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

Development of hydropower in Baja California (Baja) has been limited due to its arid climate. According to the Baja's state government website, Baja is 27,636 square miles in size and has very few lakes, rivers, and springs. Some parts of the state receive less than 7.0 inches of average annual rainfall. The only notable developable hydropower sites are located in the Valley of Mexicali. These two sites would utilize water conveyance in Mexicali's irrigation system with a combined total of 15 MW.

In summary, Baja California's hydropower resources are poor compared to the other regions under study for RETI. Furthermore the climate and size of the projects lend themselves to be more efficiently used locally.

6.6.11 British Colombia Hydropower Potential

British Columbia's hydropower potential falls in the strongest areas for hydropower resources. With an area of 364,774 square miles and an average annual rainfall of approximately 44 inches, British Columbia hydropower development tends to be large with much of the resource located on mountainous ridges. Table 6-25 shows the potential capacity from small hydropower in the province of British Columbia.

The data was analyzed from the Small Hydro Atlas. This database does not distinguish between undeveloped sites and incremental generation from existing sites. However, it is believed that all sites represent new developments. It may be difficult for small-scale hydroelectric facilities. A more detailed review of transmission issues is recommended in the next phase of this study to identify specific sites.

6.6.12 Hydropower Summary & Location Map

Table 6-30 summarizes the potential energy capacity in the RETI region based on information readily available from INL, CFE, and CanREN. Generally lower sites in the range of 1 MW to 10 MW were considered not as economical atsuch sites to qualify for the California RPS.

Table 6-29. British Columbia Developable Hydropower Technical Potential.

	Undeveloped Sites*		Total
	<10 MW	10-30 MW	
Total	**1,079**	**304**	**1,384**

Source: www.small-hydro.com
*There was no differentiation provided regarding existing projects with or without installed power. It was assumed all projects had existing power generation capacity.

Although British Columbia has great potential (1.38 GW) for hydroelectric power, it is mostly in small (<10 MW), undeveloped sites (435 locations). There are 22 sites that have between 10 and 30 MW of capacity, with a total potential of 304 MW.

Formatted: Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0" + Tab after: 0" + Indent at: 0"

Deleted: Bordering the Sate of Washington to the north and with

Deleted: One of

Deleted: largest producers of electricity is the provincially-owned electric utility BC

Deleted: . According to CanREN, about one-tenth of the electricity generated in a Canada is exported to the United States. Canadian electric utilities and industrial producers generated approximately 353,000 gigawatt hours of electricity in 2002. Currently the capacity of small hydroelectric facilities in Canada is about 2,000 MW. Natural Resources Canada (NRCan), a science-based department in the Canadian Government specializing in the sustainable development and use of natural resources, has identified approximately 1,650 MW of economically feasible potential in Canada.¶
In summary, there are many potential

Deleted: identified above 10 MW. This is because smaller site generation revenues tend to be offset by O&M costs.

Formatted Table

Deleted:

Deleted: Renewable Energy Capacity in the RETI Region (Nameplate MW).

Formatted: Tabs: 6.04", Right

... [9]

Deleted: 5

Formatted: Font: Bold

Deleted: 0

Formatted: Font: Bold

Deleted: 5

Formatted: Indent: Left: 0.13"

Formatted Table

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Deleted: British Columbia ... [10]

6.6.13 Hydropower Summary

Table 6-30 summarizes the potential energy capacity in the RETI region based on information readily available from INL, CFE, and the Small Hydro Atlas. Generally, lower sites in the range of 1 MW to 10 MW generation capacities were considered not as economical as sites identified above 10 MW. This is because smaller site generation revenues tend to be offset by O&M costs.

Table 6-30. Potential Hydropower Capacity in the RETI Region (Nameplate MW).

	Capacity of Sites < 10 MW	Capacity of Sites > 10 MW	Total Capacity
Arizona	0	0	0
Baja California	15	0	15
British Columbia	1,079*	304*	1,384
California	124	159	284
Nevada	8	0	8
Oregon	32	0	32
Washington	58	133**	191
Total	1,316	596	1,914

Sources: as identified in the report
* Not clear these sites would be eligible for the California RPS
** Excludes large upgrades at John Day and Grand Coulee

In general, the prospects for new hydropower large enough to be of interest to RETI are extremely limited in Arizona, Baja California, Oregon and Nevada. This is understandable since most of these states with the exception of Oregon consist mainly of arid plains where precipitation is very low. Geography, in conjunction with the dry climates limits the potential for hydropower generation.

Although British Columbia, California, and Washington have higher annual rainfalls, the remaining hydropower potential that could be developed for RETI is not large. If all the projects larger than 10 MW in these three regions were pursued, a total of 596 MW could be generated. Compared with the resource potential of other renewable technologies, the generation potential of hydro is relatively insignificant. Furthermore, the majority of candidate projects are relatively small and isolated. Due to the small potential of the candidate hydro projects, Black & Veatch does not recommend that RETI Phase 1B consider specific hydro project opportunities. However, development of hydro projects is expected to occur to meet California RPS requirements, and an assumption will be made to account for this development (in aggregate) in RETI Phase 1B.

Deleted: 13
Deleted: 0
Formatted: Font: Not Bold
Formatted: Table Header 1
Deleted: 13
Formatted Table
Deleted: Oregon [a]
Deleted: 81
Deleted: 66
Deleted: 147
Deleted: Washington [a]
Deleted: 1
Deleted: 244
Deleted: 359
Deleted: Source: ¶
[a] INL¶
[b] Comision Federal de Electricidad¶
[c] CanREN, unknown distribution in British Columbia, assumed 10% of Canada's national identifiable av ... [11]

2,106 to 2,387 MW of new wind capacity across nine PPAs in California.[33] Most of this is a single 1,500 MW PPA in Tehachapi. There are also 12,500 MW of wind capacity in the CAISO queue (Table 6-35).

Table 6-35. CA ISO Queue by County.

County	MW
Kern	5,949
San Bernardino	2,634
Solano	1,147
San Diego	661
Riverside	545
Santa Barbara	265
Lake & Sonoma	201
Lassen	201
Monterey	200
Lake and Colusa	200
Marin	175
Kern and Inyo	120
Shasta	102
Contra Costa	100
Source: ISO.	

6.7.3 Arizona Wind Potential

Compared to the rest of the region of study, Arizona has relatively poor quality wind resource. There are 2,553 MW of capacity potential in areas with class 4 winds or greater. Much of the wind resource in Arizona is considered to be Class 2 or less, which is generally considered to be non-economic. There is one large area of Class 3 winds, which is considered marginal wind resource. This resource is in a long line that passes near Flagstaff and continues to the eastern part of the state. Higher wind resources are predicted to exist along ridgelines as well. The map in **Error! Reference source not found.** at the end of this section shows the Class 3 and above wind resources in Arizona.

Table 6-36 shows the theoretical potential capacity from wind power class in seven regions in Arizona as estimated by NREL. The regions correspond to the large

[32] AWEA
[33] CEC

6.7.4 Nevada Wind Potential

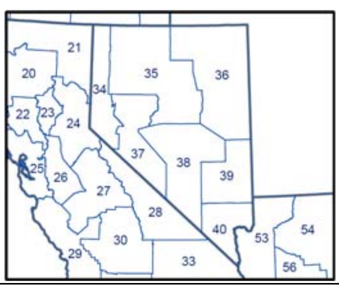
Nevada has relatively modest wind potential, and most of the resource is non-contiguous and located on high ridgelines. There are some fairly large areas of class 3 winds, which are considered marginal wind resources. These are located in southern Nevada near Las Vegas and near Ely. Higher wind resources are predicted to exist on the higher ridge crests throughout the state although these are relatively expensive to construct. The map in **Error! Reference source not found.** at the end of this section shows all the wind resources in Nevada.

Table 6-37 shows the theoretical potential capacity from wind power class in seven regions in Nevada as estimated by NREL. The regions correspond to the large regions shown in the wind resource map. The greatest potential is shown in Region 36 (northeastern Nevada), which contains most of the large areas of Class 4 winds.

Table 6-37. Nevada Wind Technical Potential.

	Capacity by Wind Power Class				Total
Region	**4**	**5**	**6**	**7**	**Capacity**
34	608	276	200	73	1,156
35	718	250	101	12	1,081
36	1,294	374	186	50	1,905
37	597	189	104	45	935
38	453	109	28	1	591
39	165	34	16	1	215
40	235	49	12	0	295
Total	4,068	1,281	646	183	6,178

Source: NREL, 2006.



There is 1,500 MW of wind capacity in Clark County (southern Nevada) in the CAISO queue, and one announced project on the Idaho-Nevada border. Nevada wind projects are hampered, however, by transmission and permitting issues. The direct transmission from northern Nevada to California is limited to lines less than 230 kV. Larger transmission lines between these two areas are all routed through Oregon and Utah. Projects in southern Nevada face significant airspace and environmental permitting issues.

6.7.5 Oregon Wind Potential

Oregon has relatively good wind potential, with nearly 2,000 square kilometers of class 4 and greater resources, although most of this is concentrated on ridge crests throughout the state. The most significant non-ridge crests areas with at least good resource are located at Vansycle ridge in northeastern Oregon, the area south of the Columbia River east of the Dalles, and southeast of La Grande. The map in **Error! Reference source not found.** at the end of this section shows all the wind resources in Oregon.

Table 6-38 shows the theoretical potential capacity from wind power class in ten regions in Oregon as estimated by NREL. The regions correspond to the large regions shown in the wind resource map. The greatest potential is shown in Region 16 (northeastern Oregon along the Columbia River), which contains most of the large areas of Class 4 winds. This theoretical or technical potential is not bound by the constraints of product availability (backordered turbines, for instance), site-specific constraints such as transmission capacity, environmental restrictions, or cost. The next phase of this study identifies the near-term developable potential for wind. This is a much smaller set of resources that could potentially be built and financed in the near term.

6.7.7 British Colombia Wind Potential

British Columbia's wind potential falls in the middle range, with the strongest areas of fair-to-good resource located at the northwest coast, the northern part of Vancouver Island. There are fairly large areas of Class 3 - 4 winds, which are considered fair to good. Much of the resource is remote and or located on mountainous ridges.

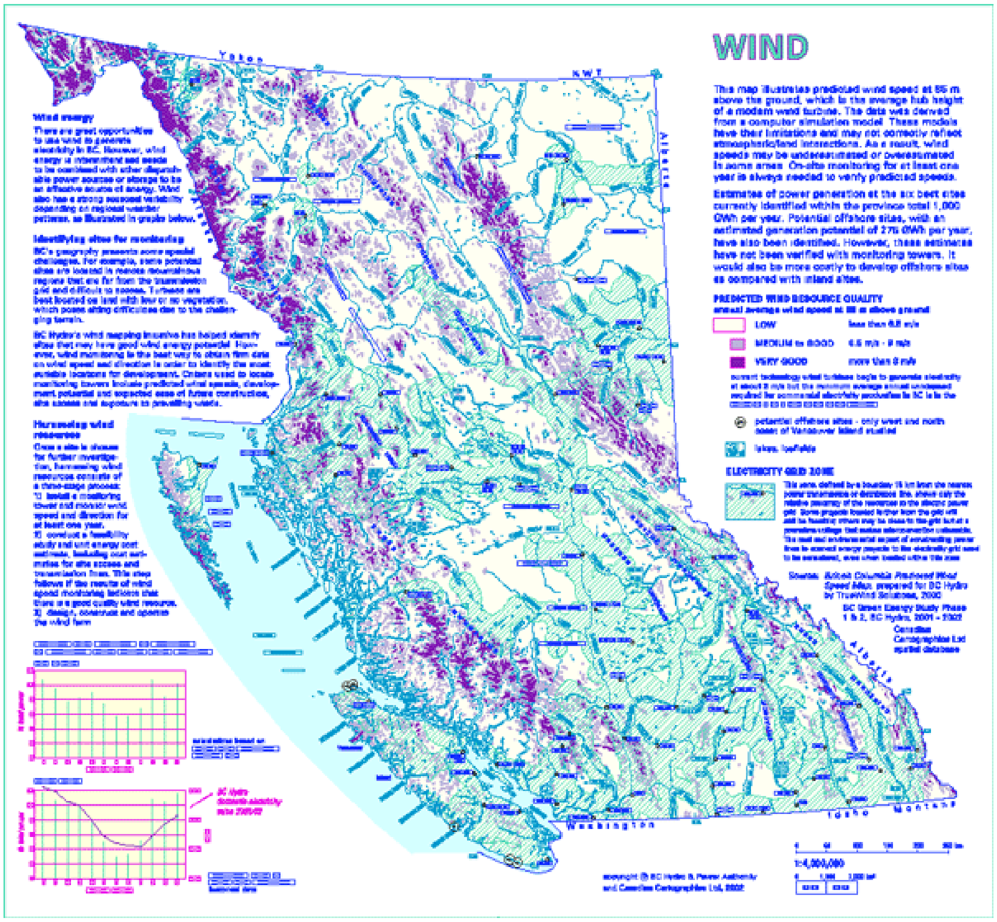


Figure 6-10. Wind Resources in British Colombia. Source: Canadian Cartographics Ltd.

Garrad Hassan performed an independent assessment of the energy potential and estimated costs of wind for BC hydro in 2007. This assessment found potential for 237 wind sites withing the province of British Columbia, totaling 36 GW of wind. Their study examined the wind energy potential of sites with Investigative Use Permits in preselected areas, namely Vancouver Island, the North Coast, the Peace region, and the Southern and Eastern Interior.

Deleted: Helimax Energy Inc. did a detailed conceptual evaluation of the top wind sites and indicated a total potential installed capacity of 4,790 MW with the sites ranging from 40 to 2,780 MW of installed capacity. Their study examined the wind energy potential of certain pre-selected areas, namely Port Alice, Port Hardy (both on northern Vancouver Island), and Prince Rupert in the northern coast area.¶

Table 6-40. British Columbia Potential Wind Project Capacities.

Areas	Number of Sites	MW of Potential
Vancouver Region Onshore	41	3,576
North Coast Region Onshore	26	4,310
Peace Region	96	18,470
Southern and Eastern Interior Region	74	9,690
Total Onshore Wind	***237***	***36,046***
Vancouver Region Offshore	6	1,950
North Coast Region Offshore	11	14,570
Total Offshore Wind	***17***	***16,520***

Source: Garrad Hassan (2007): Assessment of the Energy Potential and Estimated Costs of Wind Energy in British Columbia

Formatted Table

Deleted: Capacity (MW)

Deleted: Areas ... [12]

British Colombia currently has no operating wind facilities, but there are several proposed projects. Transmission lines exist near the larger Class 3 areas. A more detailed review of transmission issues is needed (next phase of this study).

6.7.8 Baja California Norte Potential

Baja California Norte has relatively modest wind potential, with the strongest areas of good-to-excellent resource located in the central part of the state. There are fairly large areas of class 3 - 6 winds, which are considered fair to outstanding. They are concentrated in the Rumorosa mountain range and at the Canon de San Marin in the Valle de la Trinidad. Ridge crest locations throughout the region can also have outstanding wind resource.

Table 6-43. Summary of Wind Resources.

	MW*	Assess in Phase 1B?	Notes
Arizona	2,553	No	Limited resource most likely used in state
Baja California	1,800	Yes	No PTC
British Columbia	36,046	Yes	Distant transmission, no PTC
California	21,099	Yes	
Nevada	6,178	Only S. NV	Much of resource is difficult ridge top
Oregon	7,226	Yes	
Washington	9,544	Yes	
Grand Total	53,190		

Notes:
* Nameplate capacity, Class 4 and higher. Estimates for Baja California and British Columbia based on Anders et al. (2005) and Garrad Hassan (2007), respectively.

Deleted: 4,790

Deleted: Helimax Energy (2002

Black & Veatch recommends including wind resources in California, Washington, Oregon, Southern Nevada, Vancouver Island, and Baja California for further study in Phase 1B.

6.7.11 Data Sources

Data sources used in this analysis included:

- AWEA, "U.S. Energy Projects", available at: http://awea.org/projects/ , accessed: March 13, 2008.
- AWS Truewind, LLC, "Intermittency Analysis Project: Characterizing New Wind Resources in California", available at: http://www.energy.ca.gov/2007publications/CEC-500-2007-014/CEC-500-2007-014.PDF , accessed: July 10, 2007.
- CAISO, "The California ISO Controlled Grid Generation Queue", available at: http://www.caiso.com/14e9/14e9ddda1ebf0.pdf , accessed: March 13, 2008.
- Donna Heimiller, an NREL GIS analyst.
- Garrad Hassan, "Assessment of the Energy Potential and Estimated Costs of Wind Energy in British Columbia", available at: http://www.bchydro.com/info/iep/iep53123.html, accessed April 10, 2008.
- Michael Dvorak, Mark Jacobson, and Cristina Archer, "California Offshore Wind Energy Potential", available at:

Deleted: Helimax

Deleted: , "

Deleted: Study

Field Code Changed

Deleted: http://livingoceans.org/oilgas/oilandgasreports/windenergy.pdf

Deleted:

Deleted: : February 21

Table 6-45. West Coast Tidal Resource of North America and Canada

Location	Available Resource (1) MW	Extractable Resource (Black & Veatch) MW	Rated Electrical (Black & Veatch) MW
British Columbia	4,015	602	1463
(Vancouver Island Total)	3,580	537	1304
Seymour narrows	786	118	286
Northern Boundary Pas.	366	55	133
Discovery Pass S	327	49	119
Boundary Pas.	265	40	97
Current Passage 2	208	31	76
Weyton Pas	200	30	73
Current Passage 1	139	21	51
Dent Rapids	133	20	48
South Pender Is	101	15	37
Yaculta Rapids	94	14	34
Arran Rapids	89	13	32
Secheldt Rapids 2	76	11	28
Gillard Passage 1	52	8	19
Scott Channel	51	8	19
Active Pass	50	8	18
Nahwittis	45	7	16
Nakwakto Rapids	164	25	60
Washington	100	15	36
Oregon	Not available		
California	237	36	86
TOTAL	4352	653	1585
Source: North America In Stream Tidal Power Feasibility Study; Final Briefing, EPRI			

Deleted: 870.4

Deleted: 2114

6.9.4 Future of Marine Current Installation on North America's West Coast

There are many developers worldwide seeking the most commercially competitive technology; however, to date there has been a limited number of commercial scale tidal stream technologies installed in the offshore environment. This is expected to change in 2009 when at least four further technologies are expected to be installed at

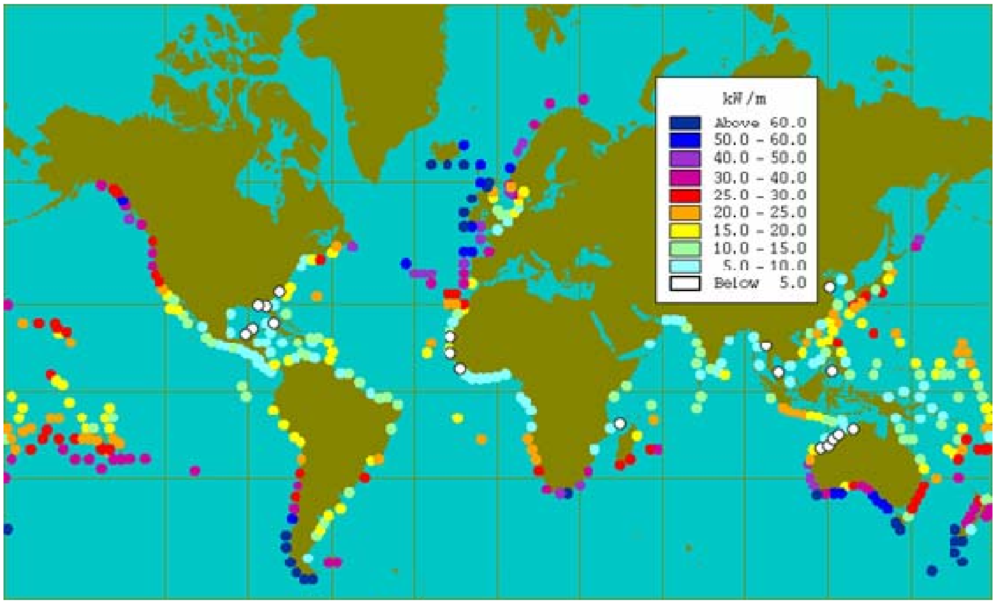


Figure 6-25. Global Wave Energy Potential. Source: EPRI.

6.10.3 British Columbia Wave Energy Potential

The Canadian Hydraulics Center conducted a study of wave resources in 2006[45]. It was estimated that the annual mean wave power along the 1,000m isobath off the Pacific coast of British Columbia totals roughly 37 GW. This is a cumulative estimate of an extremely variable resource, and it is likely that a good percentage of it would be inaccessible for the purposes of RETI. It is also an estimate of the available energy. The rated energy, which is equivalent to the installed capacity, is included in the summary table later in this section.

Deleted: British Columbia Hydro carried out an assessment on Green Energy for British Columbia in 2001[44] which included an assessment of potential wave energy. It was estimated that 2 GW of wave energy could be available on the West Coast, and in particular two sites, each of approximately 200 MW, around Vancouver Island were identified. The whole resource for British Columbia is likely to be considerably higher than this; however, this study did not assess the inaccessible sites further north. This is available energy and the rated energy, which is equivalent to the installed capacity, is included in the summary table later in this section.¶

6.10.4 California Wave Energy Potential

The California coast line extends 1,200 km down the east side of the Pacific Ocean. A full study into the California Wave Resource was commissioned by the California Energy Commission, under its Public Interest Energy Research (PIER) program in order to establish the potential of utilizing the clean supply of energy. The data presented in Table 6-47 below are the results of the study showing the available

[45] "Inventory of Canada's Marind Renewable Energy Resources" available at http://www.oreg.ca/docs/Atlas/CHC-TR-041.pdf

they have been in the PIER study and therefore the EPRI result is higher. The resource is presented in the Table 6-48 for primary sites, and Table 6-49 for the secondary sites. This demonstrates that there is a considerable resource that California could exploit once the technology is commercially ready.

Table 6-48. Extractable Primary Wave Resource Estimate in the RETI Region.

	BC	CA	OR	WA
Available Energy (MW)	37000	21500	9280	7500
Directionality factor	0.76	0.76	0.76	0.76
Spacing factor	0.75	0.75	0.75	0.75
Absorption efficiency	40%	40%	40%	40%
Conversion efficiency	50%	50%	50%	50%
Annual Average Grid Power (MW)	4218	2450	1057	855
Equiv. AAE (TWh/year)	37	22	9	8
Rated Capacity (MW)*	14,060	8,166	3,523	2,850
TOTAL Installed Capacity (MW)	28,599			

Notes:
* Rated capacity has been calculated assuming a 30% capacity factor.

Deleted: 2000
Deleted: 228
Deleted: 2
Deleted: 760
Deleted: 15,299

Table 6-49. Extractable Secondary Wave Resource Estimate in the RETI Region.

	BC	CA	OR	WA
Available Energy (MW)	Un-known	15500	20000	10000
Directionality factor		0.76	0.76	0.76
Spacing factor		0.75	0.75	0.75
Absorption efficiency		40%	40%	40%
Conversion efficiency		50%	50%	50%
Annual Average Grid Power (MW)		1767	2280	1140
Equiv. AAE (TWh/year)		16	20	10
Rated Capacity (MW)*		5,890	7,600	3,800
TOTAL Installed Capacity (MW)	17,290**			

Notes:
* Rated capacity has been calculated assuming a 30% capacity factor.
** This excludes the secondary resource in BC.

The technology is still at an early stage of development in comparison to more established renewable energy sources. Black & Veatch feels nevertheless that in four years time a number of technologies may be commercially ready, and therefore the RETI region may experience its first wave farms. The current EPRI assessments and feasibility studies have identified a number of locations from which the current grid network is accessible. Those areas with combined resource potential are likely to be where the first farm installations are made.

Given the developmental state of the technology and the uncertainty in timing of commercial installations, Black & Veatch recommends that more detailed evaluation of wave energy not be carried forward to Phase 1B. Black & Veatch further recommends that the resource and development of the industry be re-assessed as new developments happen.

6.10.11 Data Sources

1. Carbon Trust Tidal Stream Resource and Technology Summary Report, and Resource Assessment Report, 2005 http://www.carbontrust.co.uk/technology/technologyaccelerator/tidal_stream.htm
2. EPRI, Survey and Characterization of Potential Offshore Wave Energy Sites in Oregon, 2004 www.epri.com/oceanenergy
3. EPRI, Survey and Characterization of Potential Offshore Wave Energy Sites in Washington, 2004 www.epri.com/oceanenergy
4. EPRI, California Offshore Wave Power Feasibility Demonstration Project, www.epri.com/oceanenergy
5. PIER California small hydropower and ocean wave energy resources, http://www.energy.ca.gov/2005publications/CEC-500-2005-074/CEC-500-2005-074.PDF

6.11 Summary

Table 4-1 and Table 6-53 show the summary of the technical potential for each resource across the RETI study region.

Deleted: . shows

Table 6-52. Renewable Energy Technical Potential in RETI Study Region (MW).

	AZ	Baja	BC	CA	NV	OR	WA	Total
Biomass	180	N/A	2,560	4,160	42	425	1,615	8,982
Anaerobic Dig.	18	N/A	60	293	N/A	13	203	587
Landfill Gas	10	N/A	22	139	6	23	17	217
Solar Thermal	316,628	N/A	N/A	439,948	172,181	N/A	N/A	928,397
Solar PV	N/A	N/A	N/A	17 *million*	N/A	N/A	N/A	17 *million*
Hydro	N/A	N/A	304	159	N/A	N/A	133	596
Wind	2,553	1,800	36,046	21,099	6,178	7,226	9,544	53,190
Geothermal	50	80	610	2,375	1,488	380	50	5,033
Wave	N/A	N/A	14,060	8,166	N/A	3,523	2,850	28,599
Marine Current	N/A	N/A	1,436	86	N/A	N/A	36	1,558

Sources: see individual report sections

Notes:

The estimates of technical potential are based on the following constraints, described in the Resource Screening section of the report. Additional qualifications include:

- Anaerobic Dig. Higher range of estimates shown.
- Solar Thermal Class 2 and higher, slope < 1 percent. Western Arizona, and southern Nevada.
- Solar PV Only California resources
- Hydro Projects >10 MW
- Wind Class 4 and higher resources
- Wave Primary sites, rated capacity

Deleted: .
Deleted: 8-
Deleted: 85-
Deleted: 0
Deleted: 10-
Deleted: 18-
Deleted: 181-
Deleted: 0
Deleted: 443,799
Deleted: 0
Deleted: 0
Deleted: 932,608
Deleted: 0
Deleted: 0
Deleted: 162
Deleted: 231
Deleted: 0
Deleted: 66
Deleted: 244
Deleted: 703
Deleted: 4,790
Deleted: 0
Deleted: 760
Deleted: 0
Deleted: 15,299
Deleted: 2,114
Formatted: List Bullet, Indent: Left: 0.38", Tabs: 0.38", Left + 1.31", Left
Formatted: Font: 10 pt
Deleted: 1
Deleted: resources
Deleted: and <30 MW

Table 6-53. Renewable Energy Technical Potential in RETI Study Region (GWh).

	AZ	Baja	BC	CA	NV	OR	WA	Total
Biomass	1,261	N/A	17,940	29,153	294	2,978	11,318	62,945
Anaerobic Dig.	126	N/A	420	2,053	N/A	91	1,422	3,693
Landfill Gas	70	N/A	154	974	42	161	119	1,521
Solar Thermal	756 k	N/A	N/A	1,059 k	571 k	N/A	N/A	2.4 M
Solar PV	N/A	N/A	N/A	41 M	N/A	N/A	N/A	41 M
Hydro	N/A	N/A	1,332	696	N/A	N/A	583	2,610
Wind	7,268	5,124	102,623	60,068	17,589	20,572	27,172	240,417
Geothermal	350	561	4,275	16,644	10,428	2,663	350	35,271
Wave	N/A	N/A	43,107	25,037	0	10,802	8,738	87,685
Marine Current	N/A	N/A	4,402	264	N/A	N/A	110	4,776

Sources: see individual report sections

Notes:

The estimates of technical potential are based on the following constraints, described in the Resource Screening section of the report. Additional qualifications include:

- Anaerobic Dig. Higher range of estimates shown.
- Solar Thermal Class 2 and higher, slope < 1 percent. Western Arizona, and southern Nevada.
- Solar PV Only California resources
- Hydro Projects >10 MW
- Wind Class 4 and higher resources
- Wave Primary sites, rated capacity

Based on the resource and technology assessments performed, Black & Veatch has developed a set of recommendations as to the resources that should be considered in Phase 1B. The determination of whether to include a resource and technology in Phase 1B was based on several factors including: likely ability of the resource to contribute to California RPS requirements due total resource potential, ability to cost-effectively deliver the resource to the California grid, and technology maturity. Based on these assessments, resources with limited potential to provide energy to California are eliminated from further review in Phase 1B. While there may be discrete resources in these regions that might provide energy to California, there are not sufficient resources in these areas to merit exploring potential new transmission to access these resources.

Each resource is discussed in more detail below.

Biomass - resources were identified in all states and regions, with California and the Pacific Northwest having substantial biomass resource potential. Based on the potential to meaningfully contribute to California's requirements RETI recommends that biomass resources in California, Oregon, Washington and British Columbia are considered further in the Phase 1B analysis.

Anaerobic Digestion - resources were identified in most areas, though the quantity was limited. Due to the small size and distributed nature of these resources, Black & Veatch does not recommend including anaerobic digestion resources in the Phase 1B analysis.

Landfill Gas – There is limited resource potential for landfill gas to meet the RPS requirements. Similar to anaerobic digestion, due to the small size and distributed nature of these resources, Black & Veatch does not recommend including these resources in the Phase 1B analysis.

Solar Thermal – The solar thermal resource is limited to the Southwest U.S. The resource assessment revealed substantial quantities of developable solar thermal resource. Black & Veatch recommends that solar thermal in California, southern Nevada and western Arizona be included in the Phase 1B analysis.

Solar Photovoltaic – Solar photovoltaic (PV) is unique among renewable technologies, as it can be located almost anywhere, and scaled to virtually any size. RETI Phase 1A identified a virtually unlimited amount of PV potential. For Phase 1B, Black & Veatch recommends incorporating only solar PV located in California as there is sufficient high-quality resource within in California to meet almost any level of demand.

Hydro – the Phase 1A analysis determined there is several hundred MW of potential small-scale (≥10 MW) hydro generation available in California, Washington and British Columbia. The sites identified are those with the fewest environmental concerns. This potential is small compared with other resources assessed. Black & Veatch recommends that the small hydro resources not be considered in detail in the Phase 1B analysis. Hydro's contribution to the RPS will be handled in aggregate.

Wind – Wind resources were identified in all areas, though the quality of the resource differs widely. Based on the wind quality and accessibility, Black & Veatch recommends that wind be included from all regions except Arizona and northern Nevada.

Geothermal - the Phase 1A analysis determined there is substantial geothermal development potential in California, Oregon, Nevada and British Columbia, with limited amounts elsewhere. Like hydro, geothermal has the potential to provide substantial amounts of energy. Black & Veatch recommends that geothermal located in California, Oregon, Nevada and British Columbia should be included in the Phase 1B analysis.

Wave and Marine Current – These technologies offer substantial technical potential but are unlikely to achieve a commercial level of development sufficient to contribute to California's RPS goals within the planning horizon. Black & Veatch recommends that these technologies not be brought into the Phase 1B analysis, but should be monitored for potential future inclusion in the RETI analysis.

Deleted: -30

Deleted: Oregon,

Deleted: is

Deleted: cost-effective and reliable generation that can provide substantial amounts of energy

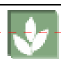
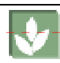
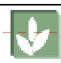
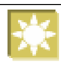
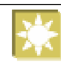
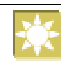
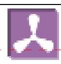
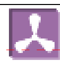
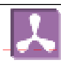
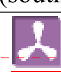
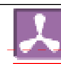
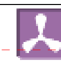
Deleted: identified between 10-30 MW

Deleted: included

The only Baja, Mexico area resource recommended for inclusion in Phase 1B analysis is wind. There is limited information regarding the resource potential in Mexico, but it is unlikely there will be significant renewable development for export, as there are no financial incentives for renewable energy development in Mexico and there is limited transmission between Mexico and California.

Table 1-4 identifies resources that are recommended for consideration in Phase 1B.

Table 6-54. Resource Recommendations for Phase 1B.

	CA	OR	WA	NV	AZ	Baja California	British Columbia
Solid Biomass							
Solar Photovoltaic							
Solar Thermal				 (south)	 (west)		
Onshore Wind				 (south)		 (north)	
Geothermal							

Deleted: , MX
Deleted: , CA
Formatted Table
Deleted: Small Hydro
Deleted: (south)
Deleted: Onshore Wind
Deleted: <sp>
Deleted: <sp>¶ (north)
Deleted: Geothermal ... [13]

7.0 Recommended Phase 1B Scope of Work

Black & Veatch is pleased to provide this draft Scope of Work for RETI Phase 1B. In RETI Phase 1A, an initial resource assessment was conducted to develop a set of potential resources to analyze further. Additionally, the methodology and assumptions required to perform this analysis were identified.

Phase 1B will build on this work, implementing the methodology to develop supply curves of renewable resources and development of Competitive Renewable Energy Zones (CREZ).

The draft RETI Phase 1B Scope of Work includes:

- Project identification and characterization
- Assessment of project characteristics
- Development of supply curves
- Integration modeling
- Development of methodology for screening and ranking projects and CREZs according to environmental impacts
- CREZ identification
- Final report preparation

In addition to the scope of work outlined in Appendix A, many other activities are expected to occur in parallel to Black & Veatch's work in Phase 1B. Most importantly, the Environmental Working Group will be developing significant data, methodological proposals, and other processes that will need to be integrated into the overall RETI process.

Deleted: costs